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FINAL REPORT:

STS-40 Descent BET Products - Development and Results

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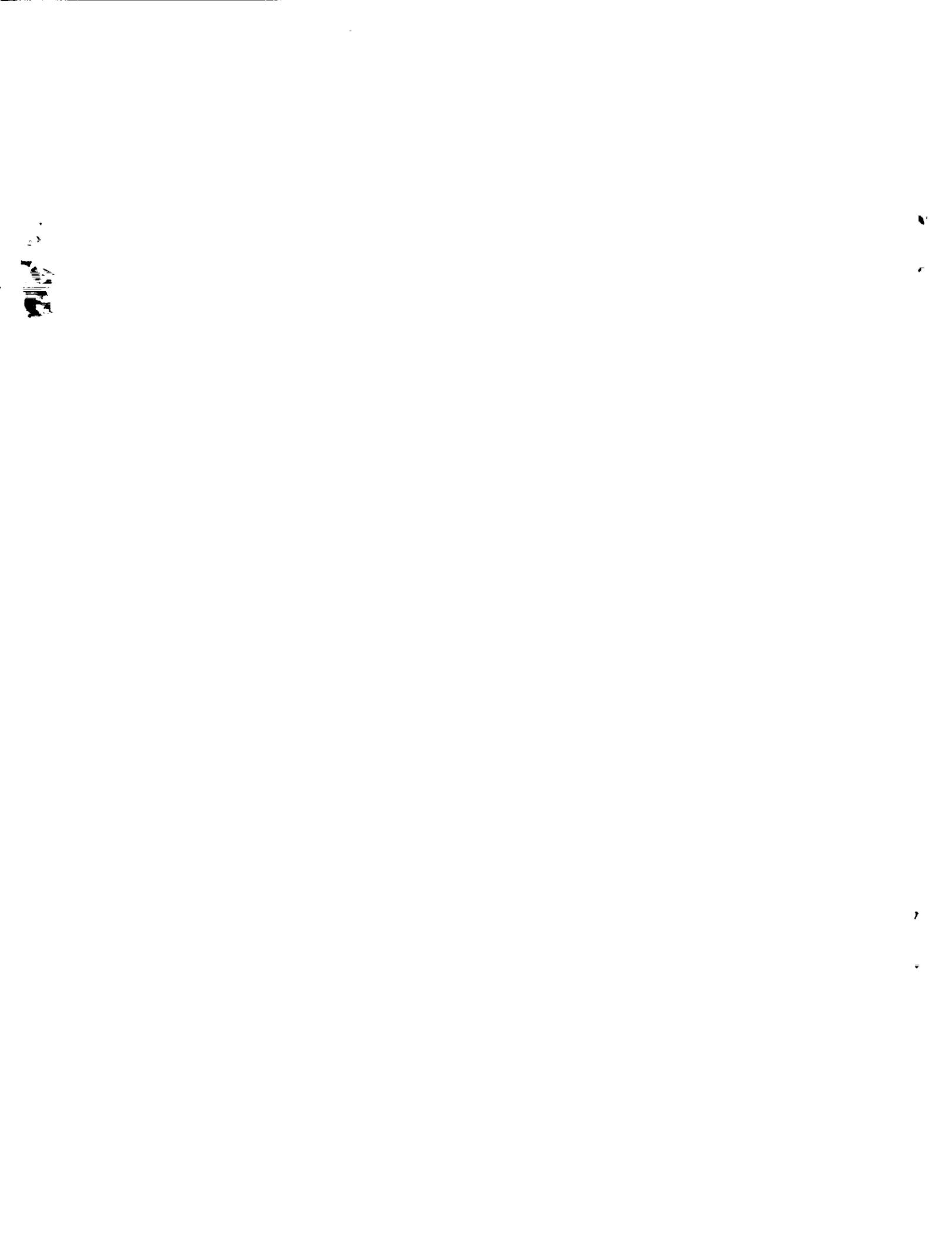
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PREFACE

This report, which documents post-flight BET results for the last OEX Shuttle Columbia flight (STS-40), completes FM&C's requirements on Task 6 of its NASA LaRC contract, NAS1-18937. Under this same task, results from STS-35 were also generated and published. Though never documented, development of similar products for STS-32 was also accomplished and these products were made available for LaRC investigations. These flight products should be of considerable value as supporting data for the ongoing Sums, SEADS, SILTS and HiRAP investigations.

The Task Monitor for this work was Mr. Paul Siemers of NASA LaRC. His efforts on our behalf are acknowledged. Moreover, the prompt delivery of much of the required data was the responsibility of Ms. Joanne Hudgins, also of NASA LaRC. Her efforts, as well as the support provided by her Unisys contractors, are acknowledged. Also, various colleagues from NASA JSC are acknowledged since their past and present support enabled the development of the capability to process the TDRSS data. Specifically, Joe Gamble, Chris Cerimele and Matt Ondler, each serving at one time or another as the PI for the APEX on the AFE project, are credited. Though this program was recently cancelled, the capability could prove invaluable for post-flight trajectory determinations on future NASA reentry vehicles, e. g., ACRV and/or PLS. Also, Don Cooper, who leads the RSOC BET activity in support of JSC, is acknowledged for providing much of the ancillary data that was required for our analysis.

Colleagues at NASA GSFC must also be acknowledged for providing the TDRSS data and associated satellite ephemeris. Included here principally are Osvaldo Cuevas and Kate Hartman (Head) of the Mission and Network Support Section. Lastly, theodolite data were available for this mission. These data, when available, have been transmitted to LaRC for post-flight trajectory determination in the past though this is the first use of such information in some time since the LaRC BET requirements have been minimal. Ms. Marion Doran at EAFB is acknowledged for providing the necessary update information to reduce these camera data.

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LIST OF SYMBOLS, ACRONYMS AND SUBSCRIPTS

A	acceleration
ACRV	Assured Crew Return Vehicle
ADDB	Aerodynamic Design Data Book
AEROBET	Aerodynamic Best Estimate Trajectory
AF'78	1978 Air Force Reference Atmospheres
AFE	Aeroassist Flight Experiment
APEX	AFE Aerodynamic Performance Experiment
ARL	aerodynamic reference line
BET	Best Estimate Trajectory
C	computed tracking observables
C_A	axial force coefficient
C_D	drag coefficient
C_L	lift coefficient
C_m	pitching moment coefficient
C_N	normal force coefficient
CDC	Control Data Corporation
CG	center-of-gravity (also c.g.)
DFRF	NASA Dryden Flight Research Facility
EAFB	Edwards Air Force Base
EFFC	FPS-16 C-band radar at EAFB (see Table 2)
EI	entry interface
ENTREE	Entry Trajectory Estimation Program
F	flight computed aerodynamic parameter
FAD	Flight Assessment Deltas
FM&C	Flight Mechanics and Control, Inc.
FPQ	C-band radar type
FPS	C-band radar type
fps	feet per second
FRCC	FPS-16 C-band radar at NASA DFRF (see Table 2)
FRFC	FPS-16 C-band radar at NASA DFRF (see Table 2)
g	gravitational acceleration
GMT	Greenwich Mean Time
GRAM	MSFC Global Reference Atmospheric Model
GSFC	NASA Goddard Space Flight Center
h	altitude above Fischer ellipsoid (ALTDE in Appendix B)
HAIR	High Accuracy Instrumentation Radar
HiRAP	High Resolution Accelerometry Package

LIST OF SYMBOLS, ACRONYMS AND SUBSCRIPTS (continued)

Hz	Hertz (Doppler units, cycles per second)
I	moment (or product) of inertia
IMU	Inertial Measurement Unit
JSC	NASA Johnson Space Center
kft	kilofeet
KMTC	Kwajalein FPQ-19 radar (see Table 2 herein) which provided both high-rate (KMTCH) and low-rate (KMTCL) data for STS-40
LAIRS	Langley Atmospheric Information Retrieval System
LaRC	NASA Langley Research Center
LHDF	down-firing RCS jets, left side
LHUF	up-firing RCS jets, left side
L/D	lift-to-drag ratio
L7	body-axis version of final pre-operational ADDB
M	Mach number (MACH in Appendix B)
MSFC	NASA Marshall Space Flight Center
M50	Mean Equator and Equinox of 1950 inertial coordinate system
NAD27	North American Datum of 1927
NASA	National Aeronautics and Space Administration
N/A	not applicable
NOAA	National Oceanic and Atmospheric Administration
O	tracking measurements
OEX	Orbiter Experiments
OI	Operational Instrumentation
OSRS	Orbiter Structural Reference System
P	roll rate
P	predicted aerodynamic parameter
PI	Principal Investigator
PLS	Personnel Launch System
PMFC	FPS-16 C-band radar at Point Mugu, California (see Table 2)
PMPC	FPS-16 C-band radar at Point Mugu, California (see Table 2)
ppm	parts per million
PTPC	FPQ-6 C-band radar at Point Pillar, California
Q	pitch rate
q	dynamic pressure (QBAR in Appendix B)
R	yaw rate
RCS	Reaction Control System
REFSMMAT	Reference matrix, stable member to Mean 1950 (Table 1)
RHDF	down-firing RCS jets, right side

LIST OF SYMBOLS, ACRONYMS AND SUBSCRIPTS (continued)

RHUF	up-firing RCS jets, right side
rms	root-mean-square
R_N	Reynolds number (RNUM in Appendix B)
RSOC	Rockwell Space Operations Company
SEADS	Shuttle Entry Air Data System
SILTS	Shuttle Infrared Leeside Temperature Sensing
STDN	Spacecraft Tracking and Data Network
STS	Space Transportation System
SUMS	Shuttle Upper Atmosphere Mass Spectrometer
S/C	spacecraft
T	atmospheric temperature
t	time from epoch
TDNR	TDRSS north ground station at White Sands, New Mexico
TDRSS	Tracking and Data Relay Satellite System
TDRS1	supporting satellite during STS-40 mission
THEO <i>i</i>	indicates <i>i</i> th cinetheodolite camera at EAFB (see Table 3)
TPQ	C-band radar type
u	southward wind component
v	westward wind component
VAFB	Vandenberg Air Force Base
VDBC	TPQ-18 C-band radar at VAFB (see Table 2)
VDFC	FPS-16 C-band radar at VAFB (see Table 2)
VDHC	C-band HAIR radar at VAFB (see Table 2)
V_A	air relative velocity (VEL A, Appendix B)
V_{bar}	hypersonic viscous interaction parameter (VBAR in Appendix B)
V_R	Earth relative velocity
WONG	vehicle weight on nose gear
WOW	vehicle weight on wheels (main gear touchdown)
YAWN	RCS yaw jets firing to produce negative yaw
YAWP	RCS yaw jets firing to produce positive yaw

GREEK SYMBOLS

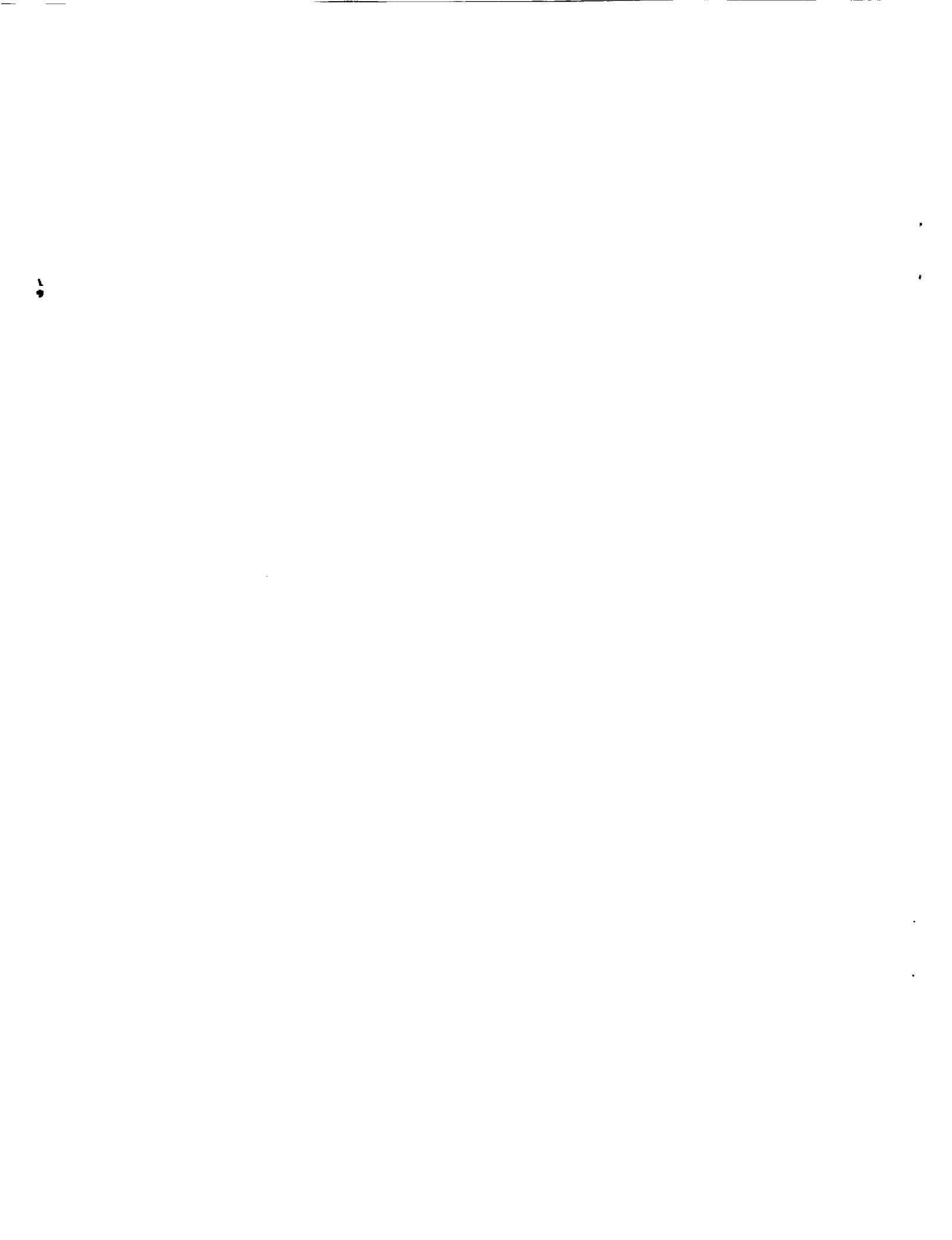
α	angle-of-attack (ALPHA in Appendix B)
β	sideslip angle (BETA in Appendix B)
γ	flight-path angle (GAM A in Appendix B)

GREEK SYMBOLS (continued)

δ	control surface deflection
Δ	denotes difference
θ	Euler pitch angle
λ	longitude
μ	mean
ρ	atmospheric density
ρ_{CN}	C_N Shuttle-derived density
ρ_{76}	U.S. 1976 Standard Atmosphere density
σ	roll angle about velocity vector (SIGMA, Appendix B)
σ	standard deviation
ϕ	Euler roll angle
Φ	latitude
ψ	Euler yaw angle
Ψ	heading angle (HDG A in Appendix B)

SUBSCRIPTS

A	aileron
A	air-relative parameter
B	body-axis parameter
b	bias
BF	bodyflap
D	geodetically referenced
E	elevator
R	planet-relative parameter
R_A	rudder, with respect to ARL
SB_A	speedbrake, with respect to ARL
W	weighted parameter
X	x-body axis
Y	y-body axis
Z	z-body axis



SUMMARY

Final post-flight descent BET results derived from the STS-40 Shuttle Columbia entry data are presented. Included are discussions and results from the inertial BET (IBETF40), Extended BET (EBETF40), and Aerodynamic BET (ABETF40). These semi-private files are resident on the CDC computers under user catalog, UN=274885C. The epoch utilized for this flight was 53,904 s GMT, June 14, 1991, corresponding to an altitude at epoch of approximately 708 kft. It is noted that this flight was the last mission to carry the complement of experiments which are of particular interest to NASA LaRC investigators, specifically, the SEADS, SUMS, SILTS and HiRAP flight experiments.

Section I. A discusses IMU data pre-processing activities. Though IMU 2 was selected as the dynamic data source for reconstruction, the equivalent body-axis dynamics derived from each of the tri-redundant IMUs compared as expected. In consort with these inertial measurements, extensive tracking data were available on this flight to assure an accurate inertial trajectory determination. Included were the multiplicity of coverages from the various C-band radars, TDRSS coherent Doppler from well above EI down to approximately 100 kft, and cinetheodolite data from five cameras obtained during the final approach and landing at EAFB. Tracking considerations peculiar to this mission are discussed in Section I. B of this report.

Though the IMU measurements compared favorably as previously noted, instrument errors were necessarily included as solution parameters in obtaining the best, contiguous, top-down fit as discussed in Section I. C. Moreover, additional observable editing, bias determinations, and inclusion of same were also required. The final maximum-likelihood estimate that best fit the measurements throughout the entire descent time frame included solving for the full Shuttle state (position, velocity, and attitude) plus the following six instrument calibrations; three accelerometer scale-factors and three gyro biases. Such an expanded state estimate is typically required. Section I. C herein presents further details as to the nature of and goodness-of-fit obtained for this flight. As a companion to these discussions, final residual plots are presented in Appendix A.

Extended BET discussions are included in Section II of this report. For that purpose, atmospheric data were extracted from the JSC descent BET - equivalently the NOAA "totem-pole" profile data. Comparisons between the Shuttle-derived density profile for this flight, as well as comparisons versus data from available models, were made in order to quantify the NOAA profile. AEROBET development is presented in Section III.

Summary results are also presented therein. Included are Shuttle configuration data and longitudinal aerodynamic performance comparisons which graphically show the differences, in percent, between flight-derived and predicted coefficients. Predicted results are based on the final pre-operational databook values, updated as relevant by the final assessment deltas derived by project aerodynamicists from earlier missions. Where possible, configuration information and aerodynamic comparisons are correlated versus ensemble results based on flights up to and including STS 61-C, the first OEX mission.

Lastly, a listing of relevant Shuttle state vector and air-data parameters from the AEROBET are included as Appendix B. Included, at a two second spacing, are altitude, velocity, flight-path and heading angles, air-relative attitude angles, Mach number, dynamic pressure and the hypersonic viscous parameter.

I. INERTIAL TRAJECTORY RECONSTRUCTION

I. A. DYNAMIC DATA PRE-PROCESSING

STS-40 OI-1 data containing the tri-redundant IMU measurements (sensed velocity changes in M50 and attitude quaternions) were provided via LaRC on a nine-track tape, NB0352. Data gaps were minimal for this flight, except for the expected mini-gaps due to the incompatability between the operating frequency of the IMUs and the downlist rate. The data were reformatted using PREOI1, edited using the PRETMS utility, and differentiated using the PREIMUS cubic-spline algorithms. Readers unfamiliar with the treatment of IMU data at LaRC are referred to the discussions presented in Part I of the ENTREE System of Software user's manual (Reference 1).

Equivalent body-axes data were derived from the triply-redundant measurements for comparison purposes as part of the editting process. These derivations require the matrices given herein as Table 1. These are the Columbia unique transformation between the navigation base and the body axes; the IMU specific matrices which define transformations between the navigation base and the outer roll gimbal (the stable member); and the REFSMMATs which orient the stable platform to the inertial system (M50). Again, readers are referred to Part I of Reference 1 for more information concerning the rigorous IMU treatment utilizing these matrices. Inspection of the STS-40 matrices indicates that IMU 2 was replaced since the last Columbia mission (STS-35) and IMU 3 was (apparently) ever so slightly realigned. In any event, the body-axes comparisons derived at the IMU downlist rate showed essentially no differences between the implied dynamics from either IMU. Even so, IMU 2 was selected since it appeared that these data were the most free of small extraneous spikes.

Figures are next included to show the IMU 2 derived body-axes dynamics during the STS-40 descent. Figure I-1 presents the spacecraft roll rate (P_B), pitch rate (Q_B), and yaw rate (R_B) versus time. Linear accelerations along the X, Y, and Z body axes are presented as Figure I-2. These data are plotted from epoch to landing, specifically WOW.

Navigation base to body matrix

0.982956500000	0.000436332300	- 0.183837900000
- 0.000452950800	0.999999900000	- 0.000048404800
0.183837900000	0.000130849300	0.982956600000

Navigation base to outer roll gimbal matrices

IMU 1	0.999999615063	0.000834364233	- 0.000271495562
	- 0.000834364202	0.99999961918	0.000000226526
	0.000271495657	0.000000000000	0.999999963145
IMU 2	0.999999440859	0.000975365476	0.000396810363
	- 0.000975369985	0.999999519528	0.000011377125
	- 0.000396799077	- 0.000011764156	0.999999921324
IMU 3	0.999991103678	0.004149357365	- 0.000754459955
	- 0.004149344133	0.999991388317	0.000019031280
	0.000754532424	- 0.000015900597	0.999999715378

Reference matrices: stable member to Mean of 1950

IMU 1	- 0.756523191929	0.009196769446	0.653902173042
	0.640452563763	0.212644159794	0.737972140312
	- 0.132261514664	0.977086365223	- 0.166760325432
IMU 2	0.210465252399	0.759719312191	0.615248620510
	- 0.326976180077	- 0.538394451141	0.776671051979
	0.921298503876	- 0.364633917809	0.135096788406
IMU 3	0.371860325336	- 0.436719596386	0.819143295288
	- 0.488393545151	0.658378183842	0.572721362114
	- 0.789424836636	- 0.613036692142	0.031533710659

Table 1. IMU matrices for STS-40.

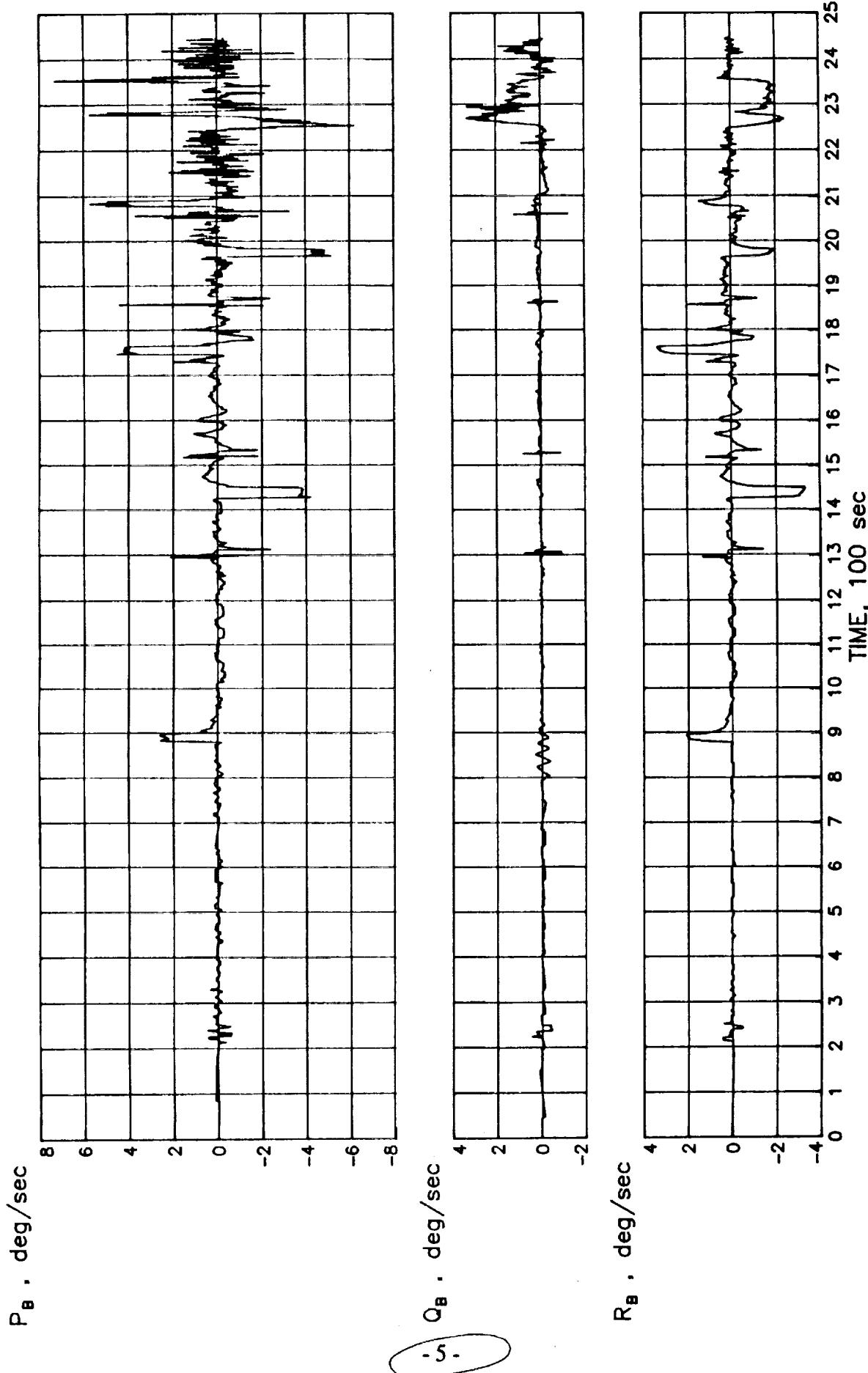


Figure I-1. STS-40 angular rates versus time, IMU 2.

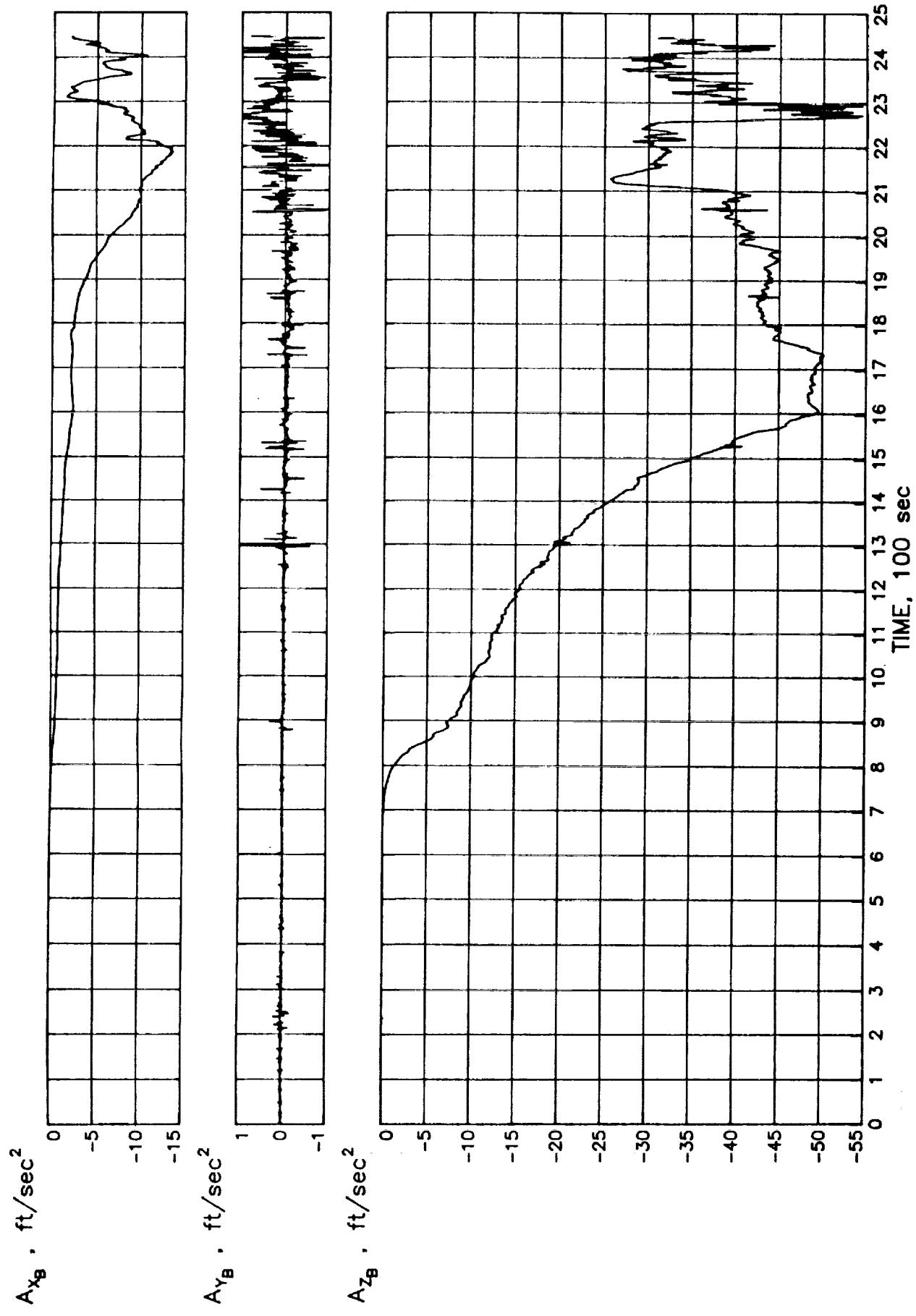


Figure I-2. STS-40 accelerations versus time, IMU 2.

I. B. TRACKING DATA PRE-PROCESSING

Considerable tracking data were available for this mission to enable an accurate trajectory reconstruction. Included were coherent S-band Doppler data from the supporting TDRSS satellite, tracking from many ground-based C-band radars, and cinetheodolite tracking from five cameras located in the vicinity of the runways at EAFB.

The TDRSS data were provided from GSFC via LaRC on nine-track reel, JHP403. These data were processed using PREOBS (unpublished) for inclusion into the ENTREE program. These data are presently available on the CDC machines as a permanent file, TDRSS40/UN=652167C. Inspection of the TDRSS coverage showed that the Doppler data were essentially contiguous during descent apart from some narrow intervals wherein increased noise was evident (perhaps due to antennae switching). Good data were available from an altitude of 986 kft down to approximately 102 kft. The data were spurious and sporadic thereafter down to approximately 50 kft. Clearly, the initial coverage was well above the corresponding altitude at the selected processing epoch for the trajectory reconstruction. As information, the supporting satellite was TDRS1, nominally located at 189° East longitude, and the supporting ground station at White Sands was the North station, TDNR. The data were available at one per second.

The C-band data were provided to LaRC by JSC as two ADDLOG tapes (Entry - JHP409 and Entry playback - JH4010) which were stripped by Unisys to isolate high- and low-rate data. Three files were created for FM&C use. These were accessed and saved as HIGH40, LOW40, and HHHH40 - all direct access files under user catalog, JSWOOD. These data were combined into a single file for PREOBS use, namely, CBAND40/UN=JSWOOD. There was coverage from eleven separate tracking stations during the STS-40 descent. Included were both high- and low-rate passes from Kwajalein and the usual coastal radar coverage, i. e., high-rate passes from Pt. Pillar, two Pt. Mugu stations, three Vandenberg stations, and three stations from the EAFB/DFRF complex. Table 2 herein presents the locations for the supporting C-band stations. Also shown thereon are auxiliary data required to calculate the refraction corrections as well as the maximum elevation angle throughout each pass. Refraction corrections are applied to those C-band observations not otherwise corrected, i. e., as indicated by a keyword on the master station characteristics summary. Again, as with STS-35, VDBC was erroneously flagged since these data had apparently been corrected. In all instances, the ENTREE software down-weights the data at the limbs as a percentage of the refraction correction to minimize the dependence on any refraction algorithms employed.

It is noted that the high- and low-rate data from Kwajalein were both from the same (KMTC) station. Since the low-rate data were determined to be independent, i. e., not a subset of the high-rate data, both passes were considered. Clearly, the maximum elevation

angle from Kwajalein was quite low, perhaps lower than one might use in most circumstances. However, in view of the added tracking geometry afforded by this coverage, these data were not deleted. Also, the tracking data from the EAFB/DFRF complex yielded essentially zenith passes. Preliminary results using these data showed residual signatures suggesting radar following concerns for the corresponding high angular rates of the antennas. Consequently, data from these stations were deleted for elevations higher than 70 degrees. In addition, the elevation component from FRCC showed a residual signal inconsistent with the other stations in the EAFB/DFRF complex and was rejected accordingly from the ensemble of observational data.

Theodolite data were delivered from EAFB and provided to FM&C on magnetic tape JHP404. An input file (THEO40/UN=652167C) was created for PREOBS. There was coverage from five cameras on this file. The necessary ancillary information to reduce these data were received from EAFB, to include the latest camera locations. These locations were in the NAD27 reference system and FM&C had to redevelop the necessary software to rotate same to the STDN of 1973 (readers can refer to Reference 2 for the required transformations). This is the coordinate system used by Space Shuttle which is, equivalently, the Fischer ellipsoid reference used for ENTREE. Table 3 shows the actual camera locations utilized. Again, as information, the maximum elevation during each pass is noted thereon.

FM&C analysts were informed by EAFB personnel that the delivered theodolite camera observations were rotated to align with a master set of axes based on a location at the end of Runway 22, the Shuttle landing runway for STS-40. Residual plots from early state-only ENTREE runs indicated that this was not the case. Residual signals improved significantly when calculated with respect to the actual locations of the individual cameras. It should also be stated that the earliest tracking passes from some of the theodolite cameras begin at a surprisingly high altitude of approximately 96 kft (slant range of greater than 350 kft to the station). FM&C analysts, concerned about possible degradations at high altitudes for otherwise highly accurate observations, used tracking arcs from the theodolite cameras beginning at a vehicle altitude of approximately 66 kft and continuing through the landing rollout.

The THEO40, CBAND40 and TDRSS40 files were combined into a single observation data file, T40OBS/UN=JSWOOD. The final file, T40OBS5/UN=JSWOOD, edited pursuant to the previous discussions, was used for the actual trajectory reconstruction. Additional editing, e. g., sigma rejection tolerances, time selection, and component rejection, can be done within the ENTREE program itself. As a final note, during the preliminary editing process there appeared to be some rather large, systematic biases in many of the C-band observables. This was not unlike the STS-35 situation. Determination of these biases as part of the entry reconstruction is discussed in the next sub-section.

Lastly, two figures are next presented to show graphically the tracking coverage geometry available. Figure I-3 shows the Shuttle entry ground-track for STS-40 on which are superimposed the locations of the various tracking stations (complexes) discussed herein. Figure I-4 shows the altitude profile with bar graphs included as an alternate display of the available coverage on this mission.

Radar Type	Acronym	Geod. Lat. (degrees)	Longitude (degrees)	Altitude (feet)	Modulus of Refraction	Scale Hgt (feet)	Max. Elev. (degrees)
FPQ-19	KMTC*	8.719500	167.718369	91.57	380	18770	4
FPQ-6	PTPC	37.497842	237.500392	-20.24	332	21679	13
FPS-16	PMPC	34.122647	240.846094	-198.79	335	21499	15
FPS-16	PMFC	34.123011	240.845125	-197.05	335	21499	15
TPQ-18	VDBC	34.665867	239.418650	202.36	334	21560	19
FPS-16	VDFC	34.583053	239.438981	1974.15	315	22690	17
HAIR	VDHC	34.758258	239.372886	10.69	337	21380	21
FPS-16	EFFC	34.970458	242.068583	2540.39	294	23893	78
FPS-16	FRFC	34.957753	242.088153	2462.07	295	23838	81
FPS-16	FRCC	34.960828	242.088561	2481.36	294	23893	80

* same KMTC location used for both high- and low-rate data

Table 2. STS-40 tracking station locations, refraction and other information.

Acronym	Geod. Lat. (degrees)	Longitude (degrees)	Altitude (feet)	Max. Elev. (degrees)
THEO1	34.9167310	242.290574	2741.97	72
THEO5	34.8390496	242.295741	2701.56	53
THEO6	34.7965863	242.169825	2303.03	43
THEO7	34.9283871	242.237693	2378.04	81
THEO8	34.9971031	242.155908	2138.95	61

Table 3. STS-40 cinetheodolite tracking cameras utilized.

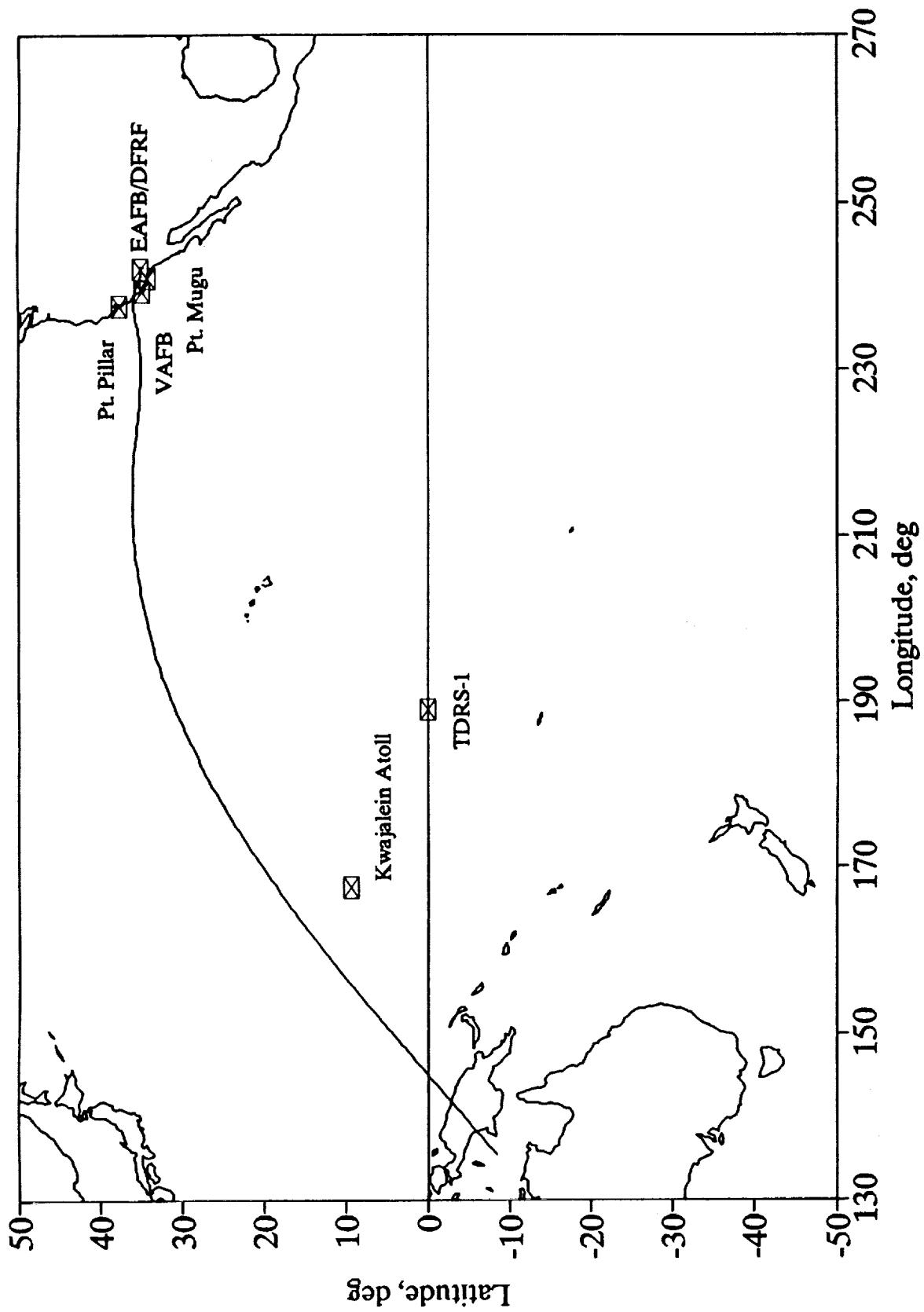


Figure 1-3. STS-40 ground track during descent

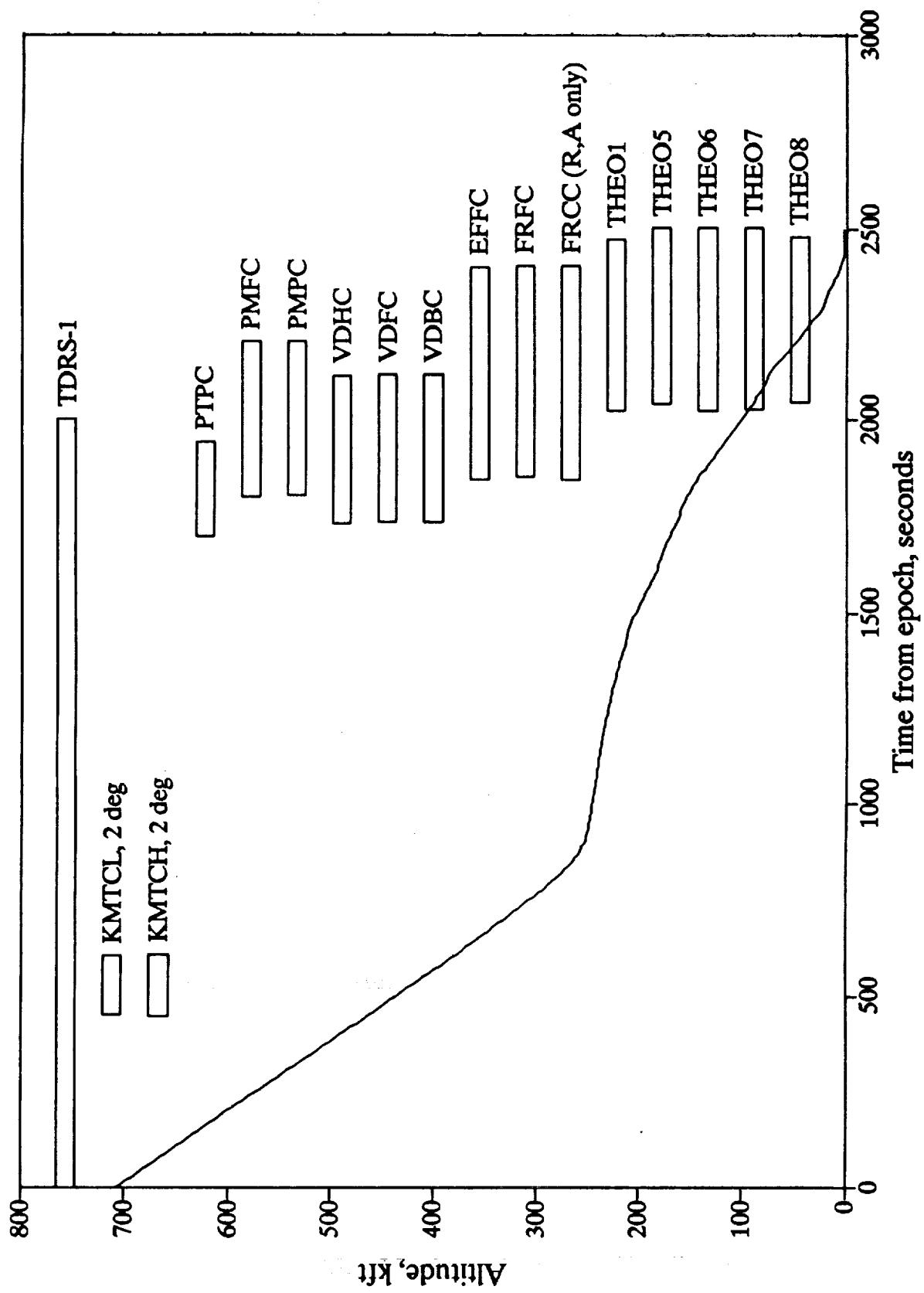


Figure I-4. STS-40 altitude profile with tracking intervals superimposed.

I. C. RECONSTRUCTION RESULTS

ENTREE reconstruction activities in support of observational data pre-processing for STS-40 concentrated on state-only estimates, where state-only refers to the nine variables which define the Shuttle position, velocity and attitude histories during descent. Though some past "final" flight determinations have involved state-only solutions, the primary purpose for these preliminary STS-40 runs was to evaluate and edit the tracking data. As previously indicated, there seemed to be large, systematic biases visible in the C-band data. Consequently, prior to finalizing the BET, efforts were expended to solidify and remove said biases.

Not unlike the previous STS-35 reconstruction, the indicated biases were significant and appeared to be most prevalent across complexes, perhaps indicating a potential trajectory error during that rather important segment of the mission covered by Pt. Mugu, Vandenberg, and EAFB/DFRF. For the most part, it did appear that all three components from this multiplicity of trackers could well be biased. However, after iterating, the following biases (Table 4 below) were determined:

STATION	COMPONENT	BIAS (feet/degrees)	WEIGHTED BIAS ($\approx\sigma$ level)
PMFC	RANGE	- 65.7	- 1.67
PMFC	AZIMUTH	- 0.01856	- 1.62
PMFC	ELEVATION	- 0.01243	- 1.08
PMPC	AZIMUTH	- 0.01111	- 0.97
PMPC	ELEVATION	- 0.00725	- 0.63
VDHC	AZIMUTH	- 0.00456	- 0.40
VDFC	AZIMUTH	- 0.01089	- 0.95
VDBC	RANGE	- 40.2	- 1.02
EFFC	RANGE	- 16.9	- 0.43
EFFC	AZIMUTH	0.00941	0.82
EFFC	ELEVATION	- 0.00637	- 0.56
FRFC	AZIMUTH	0.00814	0.71
FRCC	AZIMUTH	0.00850	0.74
THEO8	AZIMUTH	- 0.00485	- 0.85

Table 4. Tracking biases determined for STS-40.

The table, which does include one camera component, shows some biases in excess of 1.5σ . Readers should understand that these bias determinations are not unique. They were actually determined as those components whose biases remained "consistent" between a top-down state-only fit (C-band and camera data only) and a lower-end fit in which state and nine instrument parameters were estimated, the latter permitting additional degrees of freedom to fit the data in an unbiased sense where possible. There were four other significant biases indicated in the preliminary runs which were not solidly vindicated and, therefore, neglected. Prior to incorporating the TDRSS data, these biases were shown to be consistent with a top-down state plus six IMU parameter estimate. Those biases adopted remained consistent whenever the TDRSS data were included in the fitting process though, for the latter, when estimating state-only, some of the previously suspected component biases reappeared. Inclusion of additional solve-fors diminished those re-occurring, otherwise inconsistent biases. Though some biases on the order of 0.5σ remain, it was not felt that these biases would have any appreciable effect on the estimate, an assumption vindicated during the iteration process.

After further iteration, the final ENTREE maximum-likelihood estimate was generated. This solution included, in addition to the Shuttle state, some six IMU parameters. These instrument parameters were: three gyro biases and three accelerometer scale-factor errors. The IMU parameters are determined in the platform reference, i. e., the axes consistent with the actual measurements. This provides for a more rigorous model even though some liberties are taken wherein it is assumed that there are three independent accelerometers per platform rather than the two that actually exist. This approximation has been justified in the past and is consistent with the modeling done on all previous flights. FM&C's final ENTREE estimate is presented in Table 5. Included thereon is the initial estimate of the nine-state parameters obtained from the RSOC BET generated for JSC. As can be seen, spacecraft state parameters compare favorably as expected. No information is available on RSOC determinations, if any, of either instrument parameters or, for that matter, fixed observational biases, to compare any of the other parameters. Consequently, instrument parameter estimates must be compared versus "perfect" instrumentation, at least commensurate with expected levels of error. As information, gyro biases of approximately $0.022\text{ deg}/\text{hr}$ (1σ) can be expected. This is the fixed-drift component and there can be an additional g-sensitive drift component of $0.025\text{ deg}/\text{hr}/\text{g}$. The scale-factor errors shown can be compared with an expected level of 100 ppm consistent with the accelerometer specifications. As evident by inspection, the instrument parameters thus determined are significant in most components.

PARAMETER	INITIAL	FINAL
Velocity (V_R), fps	24196.99	24195.38
Flight path angle (γ_R), deg	- 1.1859	- 1.1855
Heading angle (Ψ_R), deg	49.4541	49.4539
Altitude (h), ft	707870	708426
Latitude (Φ_D), deg	- 8.4230	- 8.4235
Longitude (λ), deg	135.5442	135.5459
Euler yaw angle (ψ), deg	46.978	46.994
Euler pitch angle (θ), deg	24.149	24.116
Euler roll angle (ϕ), deg	- 3.926	- 3.869
IMU roll gyro bias (P_b), deg/hr		- 0.042
IMU pitch gyro bias (Q_b), deg/hr		- 0.021
IMU yaw gyro bias (R_b), deg/hr		0.032
IMU X-accelerometer scale-factor error, ppm		39
IMU Y-accelerometer scale-factor error, ppm		254
IMU Z-accelerometer scale-factor error, ppm		- 87

Table 5. Final ENTREE parameter estimates for STS-40.

Table 6 herein summarizes the overall fit quality. The data rate employed for the TDRSS Doppler and high-rate Kwajalein pass was one per second. All other observations were fit at one per two seconds, the exception being the low-rate Kwajalein data which were only available at a 6 second spacing. Consequently, there were a total of 9,029 observations processed. The data rejection criterion utilized was a 3σ level. The overall fit yielded a weighted mean of 0.11σ with a weighted standard deviation of 0.86σ . Individual fits, by component, can be surmised from the table. Both dimensional and weighted fit statistics are presented.

TDRSS Doppler residuals are presented as Figure I-5. These data were fit to 0.70 Hz ($\pm 0.79\sigma$). As in the past, the TDRSS data were weighted at 1 Hz (≈ 0.22 fps) even though the actual noise on these data is much less. However, on this flight FM&C did employ an antenna offset in the Doppler computations to minimize the large signal excursions occurring during periods of active spacecraft angular motion.

Final C-band and cinetheodolite residual plots are presented in Appendix A. Both the residuals and weighted residuals are plotted to indicate the "goodness-of-fit." Residual mean and standard deviation are annotated for each component. Apart from some of the remaining biases previously discussed, the only significant signatures remaining after fitting all the data are the range residuals from the two Kwajalein sources. The implied ramp could not be removed when the TDRSS data were incorporated.

Composite residuals by component for the C-band radars and camera trackers are shown in Figures I-6 through I-8 herein. Composite range residuals are presented as Figure I-6 for the radars. Composite azimuth and elevation residuals (radars and cameras) are given in Figures I-7 and I-8, respectively. Individual station signatures cannot be gleaned from these figures but such plots best reflect the overall fit to the tracking data throughout the entire entry. Though the weighted residuals are not shown, the weighted mean and weighted standard deviation are annotated on each figure along with the actual dimensional values for each component. It is noted that the camera data were weighted to be more accurate than the radar data by a factor of two.

The final inertial BET is available on the LaRC CDC machines as a semi-private indirect access file (IBETF40) under User Catalog UN=274885C. STS-40 event times of interest are listed below in terms of seconds from epoch.

Entry Interface (EI)	565
Main Gear Deployment	2428
Weight on Wheels (WOW)	2447
Weight on Nose Gear (WONG)	2461
Stop time	2501

TYPE	STATION	ACCEPTED	MEAN	WEIGHTED	STD. DEV.	WEIGHTED
			MEAN	MEAN	STD. DEV.	STD. DEV.
Doppler (Hz)	TDRS1	1805 of 1830	0.70	0.70	0.79	0.79
Range (feet)	KMTCL	25 of 26	-30.6	-0.75	57.5	1.41
	KMTCH	146 of 149	-22.8	-0.56	55.5	1.35
	PTPC	114 of 114	5.4	0.14	37.4	0.94
	PMFC	173 of 195	-13.8	-0.35	38.3	0.97
	PMPC	193 of 196	-5.7	-0.14	36.1	0.91
	VDHC	183 of 184	-21.7	-0.55	23.9	0.60
	VDFC	186 of 186	-25.3	-0.64	31.9	0.81
	VDBC	179 of 182	-24.5	-0.62	29.5	0.75
	EFFC	255 of 259	-0.3	-0.01	27.1	0.69
	FRFC	254 of 258	-6.5	-0.16	32.6	0.82
	FRCC	261 of 261	2.7	-0.07	23.9	0.60
Azimuth (degrees)	KMTCL	26 of 27	0.0029	0.25	0.0116	1.01
	KMTCH	155 of 155	0.0024	0.21	0.0095	0.83
	PTPC	121 of 121	0.0000	0.00	0.0032	0.28
	PMFC	203 of 203	-0.0008	-0.07	0.0061	0.54
	PMPC	202 of 204	-0.0014	-0.12	0.0071	0.62
	VDHC	189 of 189	-0.0007	-0.06	0.0033	0.29
	VDFC	188 of 188	-0.0008	-0.07	0.0089	0.78
	VDBC	190 of 190	0.0009	0.08	0.0060	0.53
	EFFC	211 of 237	-0.0002	-0.02	0.0140	1.22
	FRFC	252 of 260	0.0003	0.02	0.0091	0.79
	FRCC	240 of 263	0.0019	0.17	0.0108	0.95
	THEO1	142 of 143	0.0013	0.22	0.0055	0.96
	THEO5	175 of 175	0.0004	0.07	0.0046	0.81
	THEO6	161 of 161	-0.0006	-0.10	0.0040	0.70
	THEO7	151 of 156	0.0031	0.54	0.0048	0.85
	THEO8	166 of 167	0.0012	0.22	0.0039	0.68
Elevation (degrees)	KMTCL	26 of 27	-0.0092	-0.31	0.0237	0.77
	KMTCH	150 of 150	-0.0111	-0.39	0.0281	0.88
	PTPC	121 of 121	-0.0010	-0.06	0.0049	0.3
	PMFC	203 of 203	-0.0004	-0.03	0.0057	0.38
	PMPC	202 of 203	-0.0001	-0.02	0.0085	0.55
	VDHC	190 of 190	-0.0033	-0.21	0.0041	0.25
	VDFC	188 of 188	0.0019	0.18	0.0104	0.68
	VDBC	191 of 191	-0.0046	-0.31	0.0044	0.27
	EFFC	154 of 164	-0.0003	-0.07	0.0150	1.17
	FRFC	259 of 260	0.0015	0.08	0.0101	0.77
	THEO1	143 of 143	0.0010	0.18	0.0043	0.75
	THEO5	175 of 175	-0.0011	-0.19	0.0035	0.62
	THEO6	161 of 161	0.0019	0.34	0.0036	0.63
	THEO7	153 of 156	0.0029	0.50	0.0055	0.96
	THEO8	167 of 167	0.0020	0.35	0.0041	0.71

Table 6. Summary of fit statistics for STS-40.

$$\begin{array}{ll} \mu = 0.70 \text{ Hz} & \mu_w = 0.70 \\ \sigma = 0.79 \text{ Hz} & \sigma_w = 0.79 \end{array}$$

O-C, Hz.

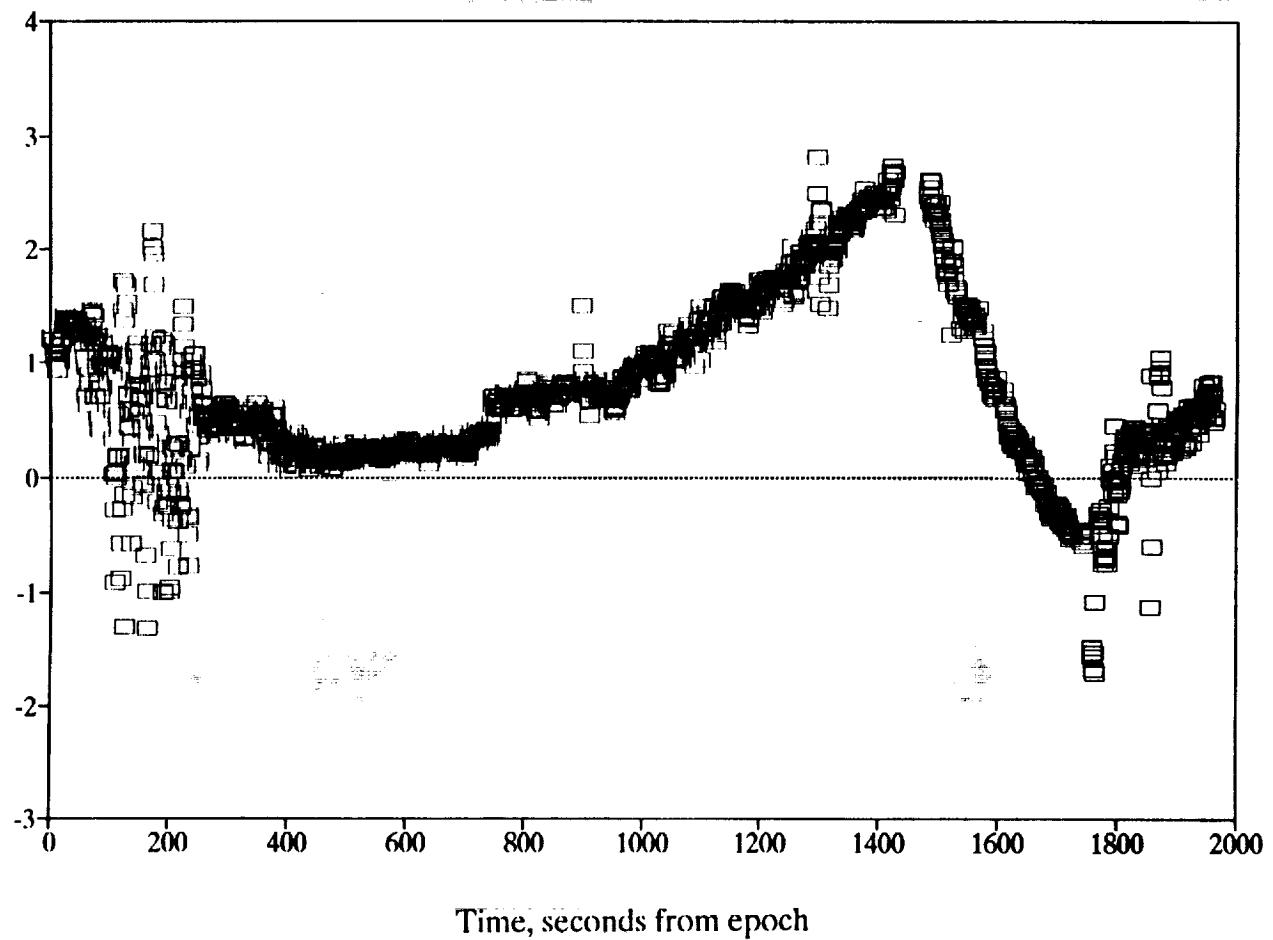


Figure I-5. Final TDRSS residuals for STS-40.

$$\begin{array}{ll} \mu = -10.74 \text{ ft} & \mu_w = -0.27 \\ \sigma = 35.57 \text{ ft} & \sigma_w = 0.90 \end{array}$$

O-C, ft.

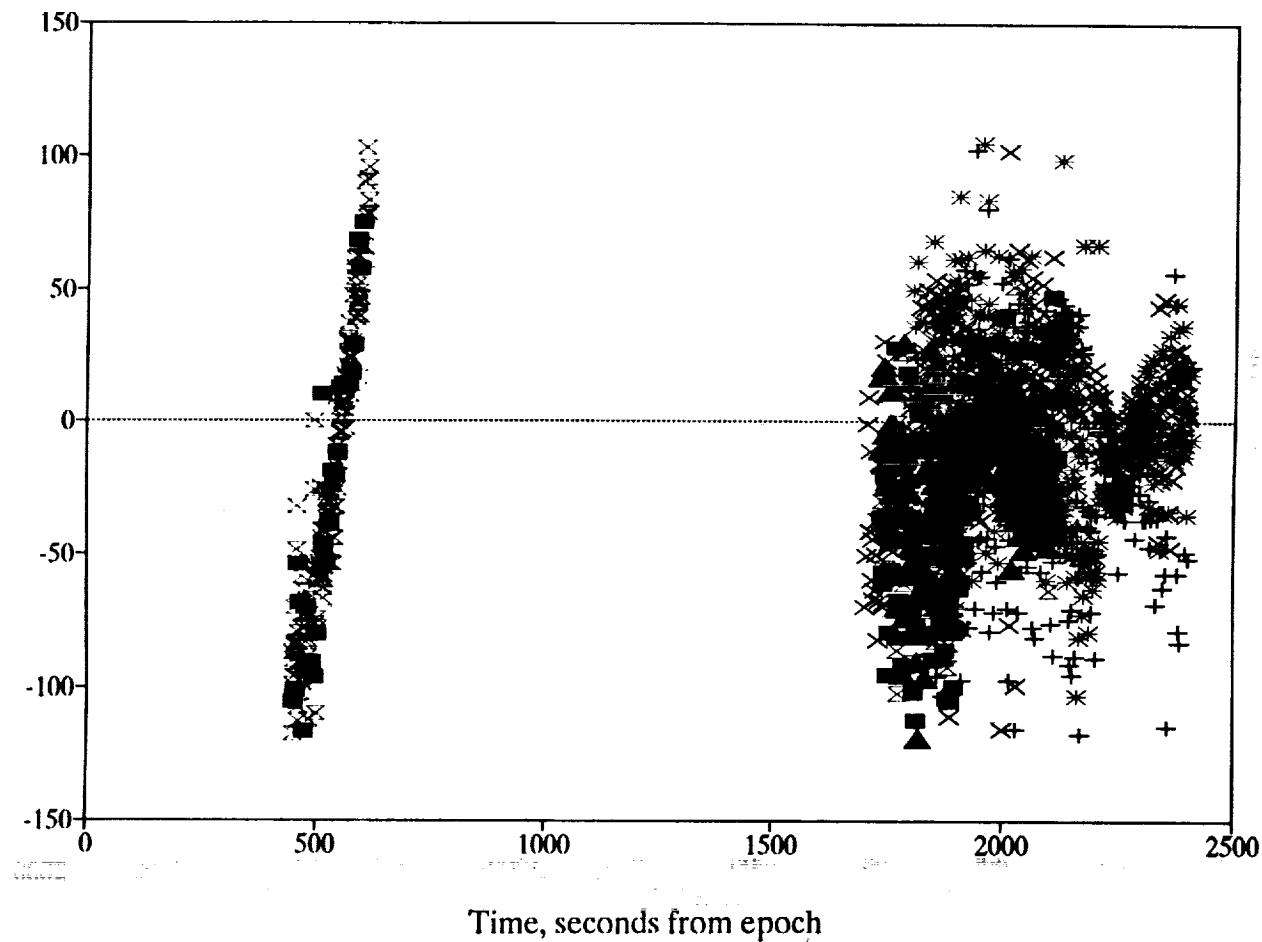


Figure I-6. Composite range residuals from STS-40 C-band stations.

$$\begin{aligned}\mu &= 0.0004^0 & \mu_w &= 0.04 \\ \sigma &= 0.008^0 & \sigma_w &= 0.69\end{aligned}$$

O-C, degrees.

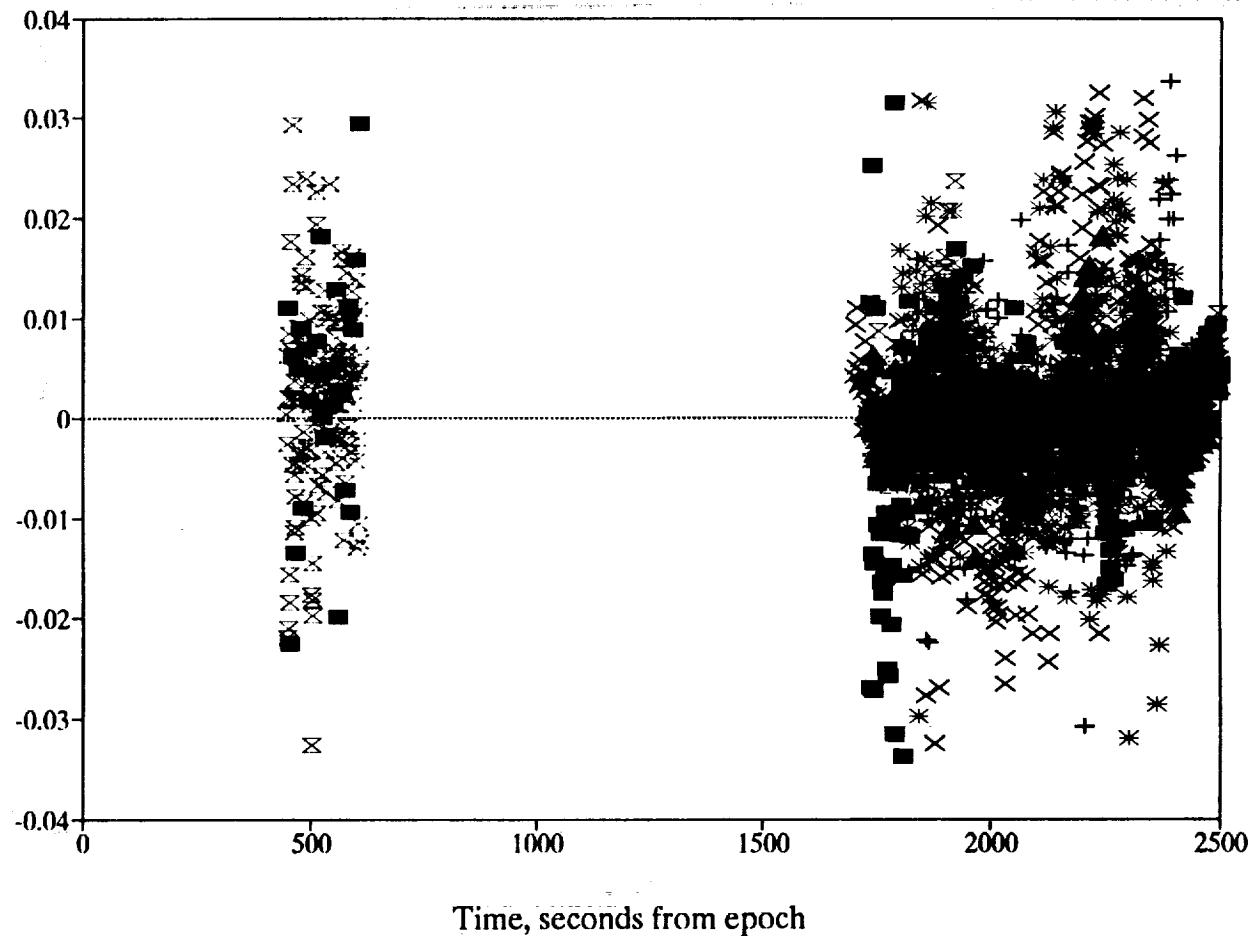


Figure I-7. Composite STS-40 azimuth residuals (C-band and cameras).

$$\begin{array}{ll} \mu = -0.0003^0 & \mu_w = -0.02 \\ \sigma = 0.008^0 & \sigma_w = 0.75 \end{array}$$

O-C, degrees.

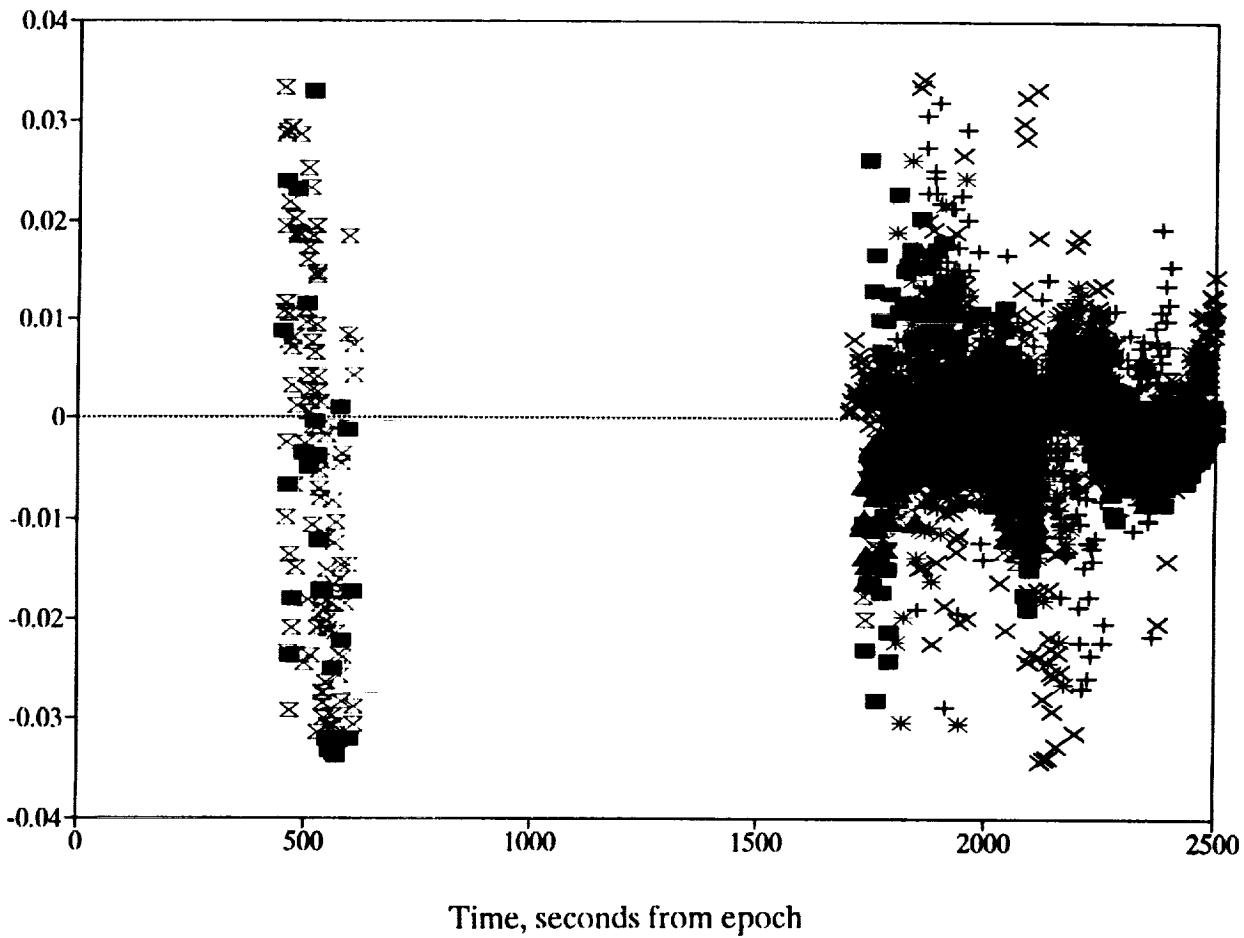


Figure I-8. Composite STS-40 elevation residuals (C-band and cameras).

II. EXTENDED BET DEVELOPMENT

Only one atmospheric source (apart from models) existed for the development of the 66-word Extended BET for STS-40. This source was the equivalent NOAA "totem-pole" atmospheres utilized by RSOC for their JSC BET development. These data are based on the remote sensing information and are delivered to JSC as specific vertical profiles spatially located in the vicinity of the ground track during descent. RSOC utilizes software to interpolate versus altitude, latitude and longitude, a process resulting in a single Shuttle-specific atmosphere. This information was reformatted from the JSC BET to conform to the expected LAIRS file structure. The file, LAIRF40/UN=JSWOOD, was then combined with the inertial BET to generate the Extended BET. Figure II-1 shows the temperature profile versus altitude. Density and pressure profiles are shown as Figures II-2 and II-3, respectively. Atmospheric winds, i. e., horizontal components, are plotted versus altitude as seen in Figure II-4. Note that the atmospheric plots are restricted to below 400 kft by definition.

As a qualitative assessment of these atmospheric data, the density and temperature profiles over the uppermost altitudes were compared using a previously developed methodology (Reference 3). These comparisons utilize Shuttle-derived results as well as data from two available, elaborate models, namely the MSFC GRAM and AF'78 models (References 4 and 5, respectively). The Shuttle-derived density profile is computed using the predicted normal-force coefficient from the L7 version of the pre-operational databook (Reference 6). These data are rectified using the flight-substantiated deltas determined by project aerodynamicists (the so-called FAD26 of Reference 7). This rectified coefficient, in conjunction with the in situ normal acceleration profile derived from IMU 2, can be utilized to calculate the atmospheric density. Pressure can then be obtained by integration of the hydrostatic equation. Finally, temperature is computed from the perfect gas law. The comparisons are shown as Figure II-5. Note that metric units are employed. Also note that the density for each of the atmospheric sources has been normalized to the 1976 Standard Atmosphere. The measured data agree quite well with that expected from the two models, particularly above 75 km. The Shuttle-derived profile is representative of a much more dynamic density profile above 80 km, exhibiting much more structure than implied from either of the other sources. This is not atypical. However, the Shuttle results agree in general with the measured data below this altitude.

The Extended BET for this flight is available on the LaRC CDC machines as EBETF40 under user catalog UN=274885C. Appendix B presents some relevant parameters from this file. Listed, at a two-second spacing, are the air-relative velocity, both the flight-path and heading angles, altitude above the Fischer ellipsoid, attitude angles with respect to the air-relative velocity vector, Mach number, dynamic pressure, and both the hypersonic viscous parameter (VBAR) and Reynolds number (RNUM). The latter two were actually taken from the Aerodynamic BET later discussed. It is noted that QBAR, VBAR and RNUM are only computed below entry interface and, in the case of VBAR, no computations are included below a value of 0.005. That is the minimum value utilized in the aerodynamic databook formulation as discussed in the next section.

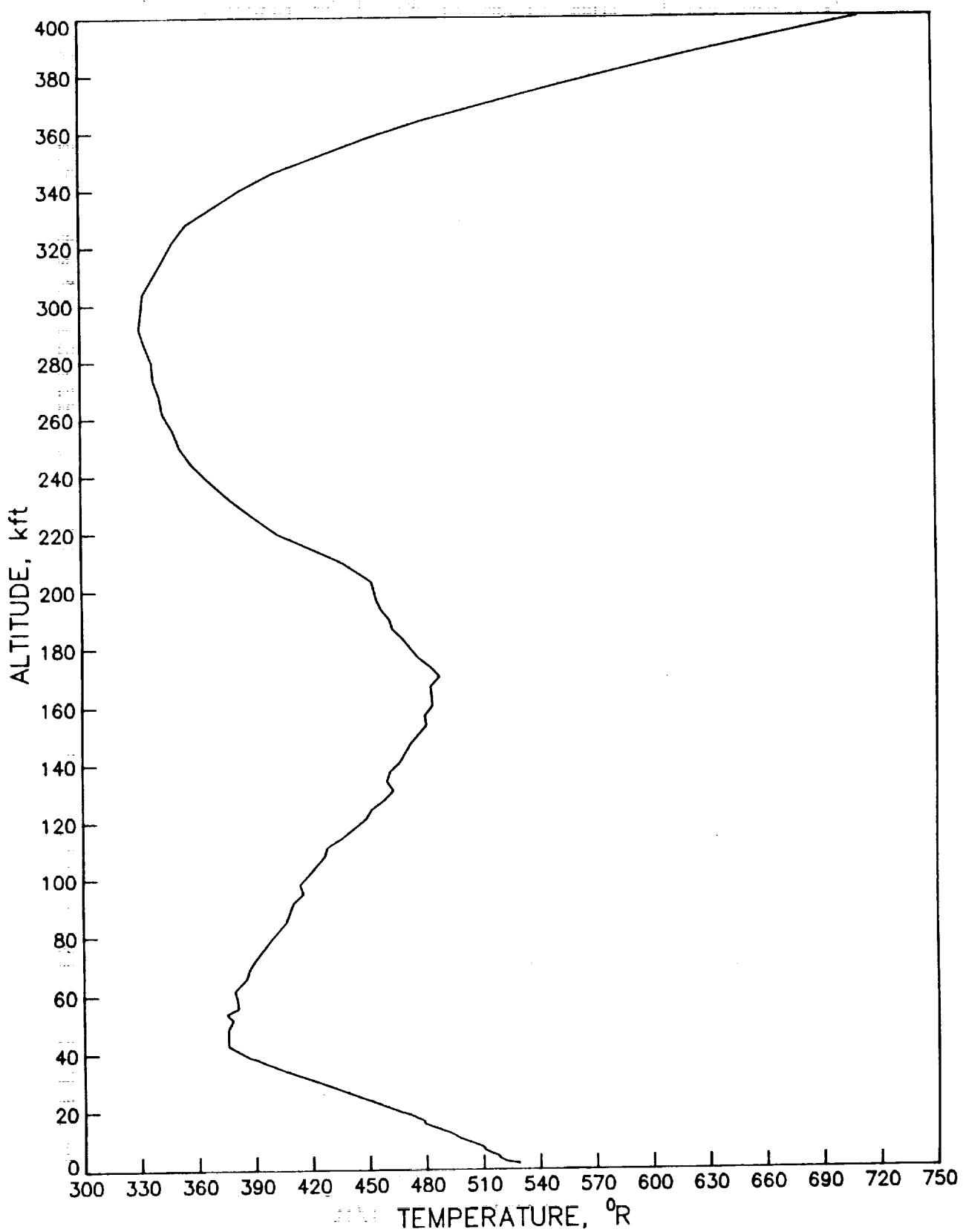


Figure II-1. STS-40 temperature profile.

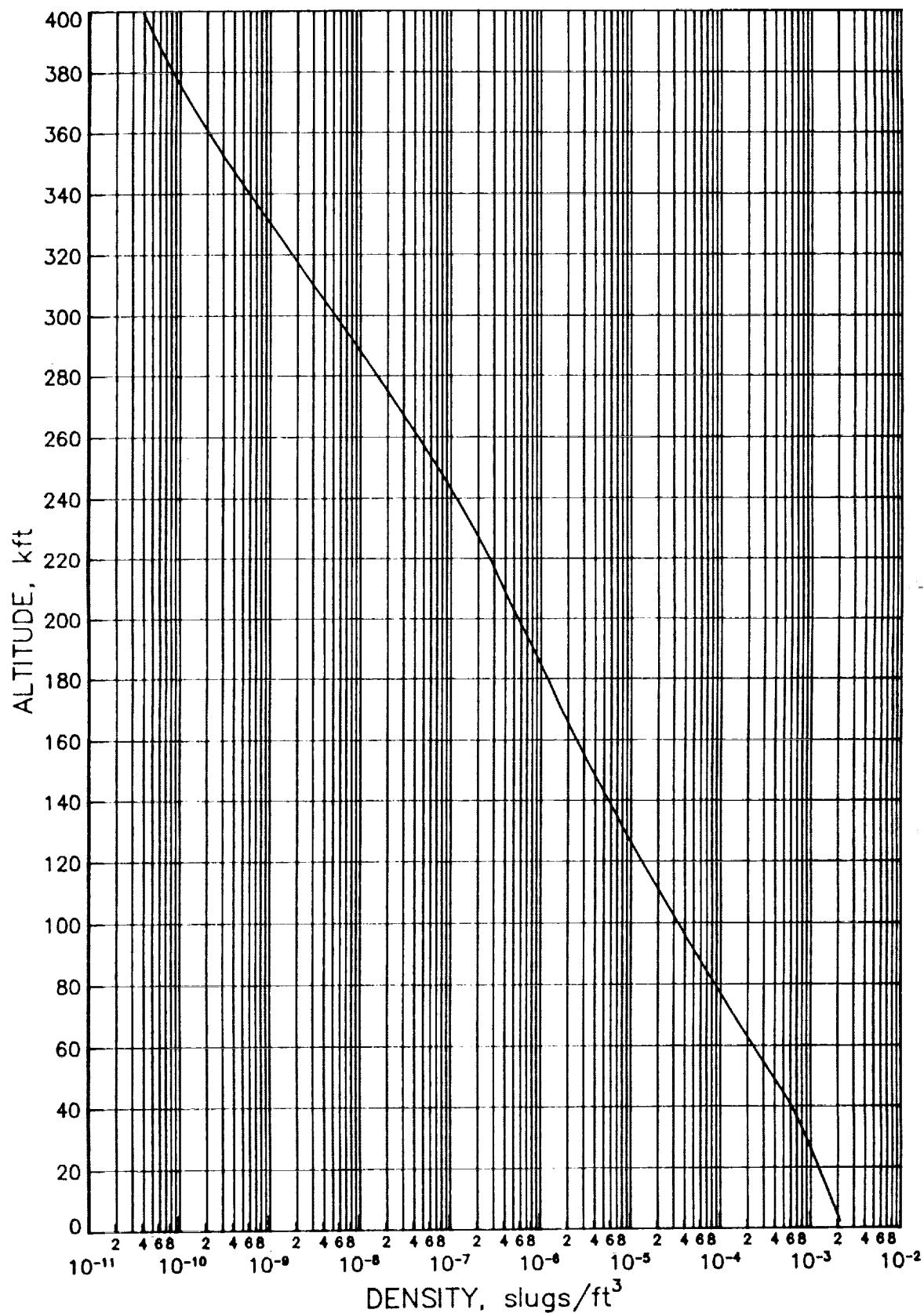


Figure II-2. Density profile for STS-40.

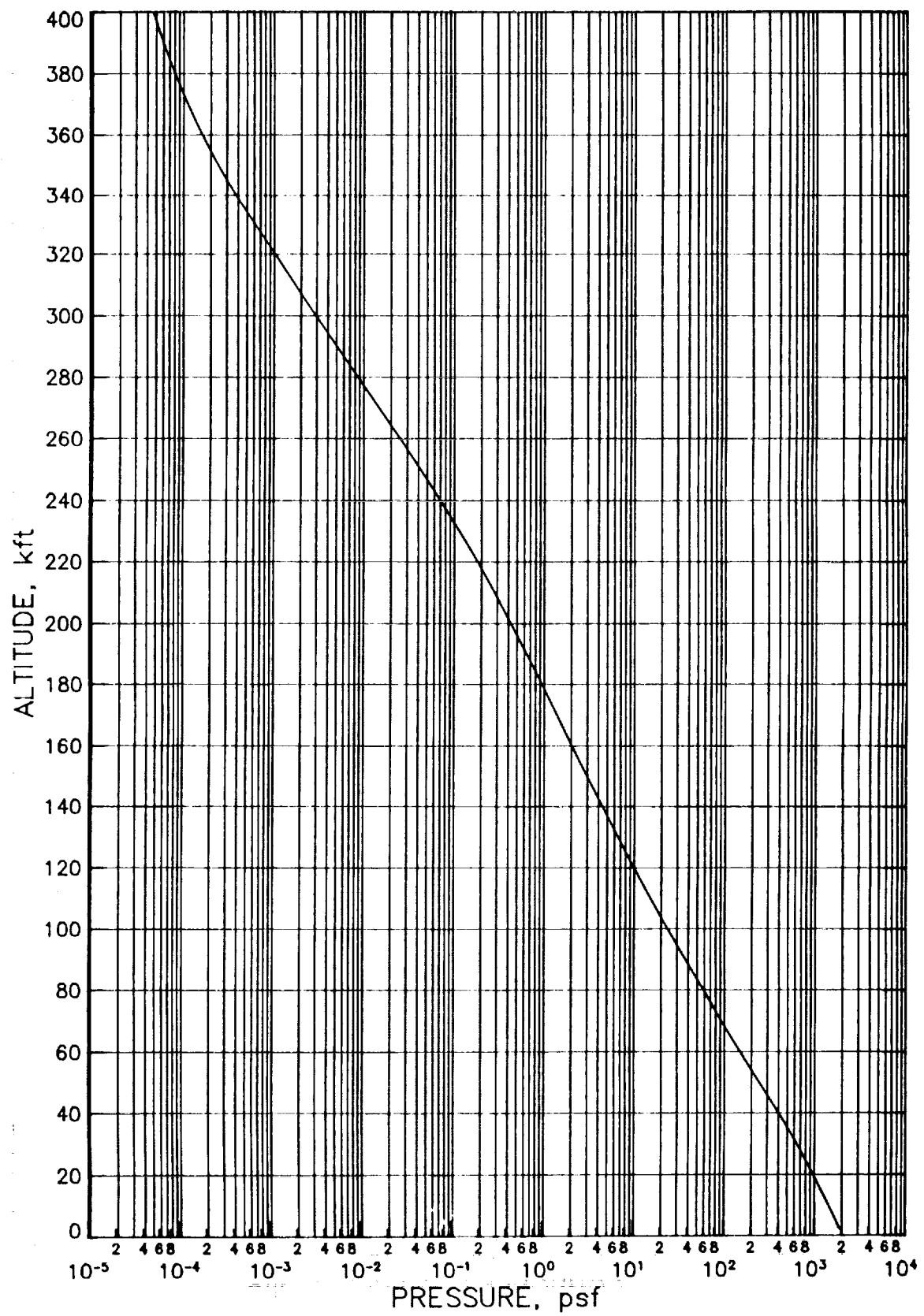


Figure II-3. STS-40 pressure profile.

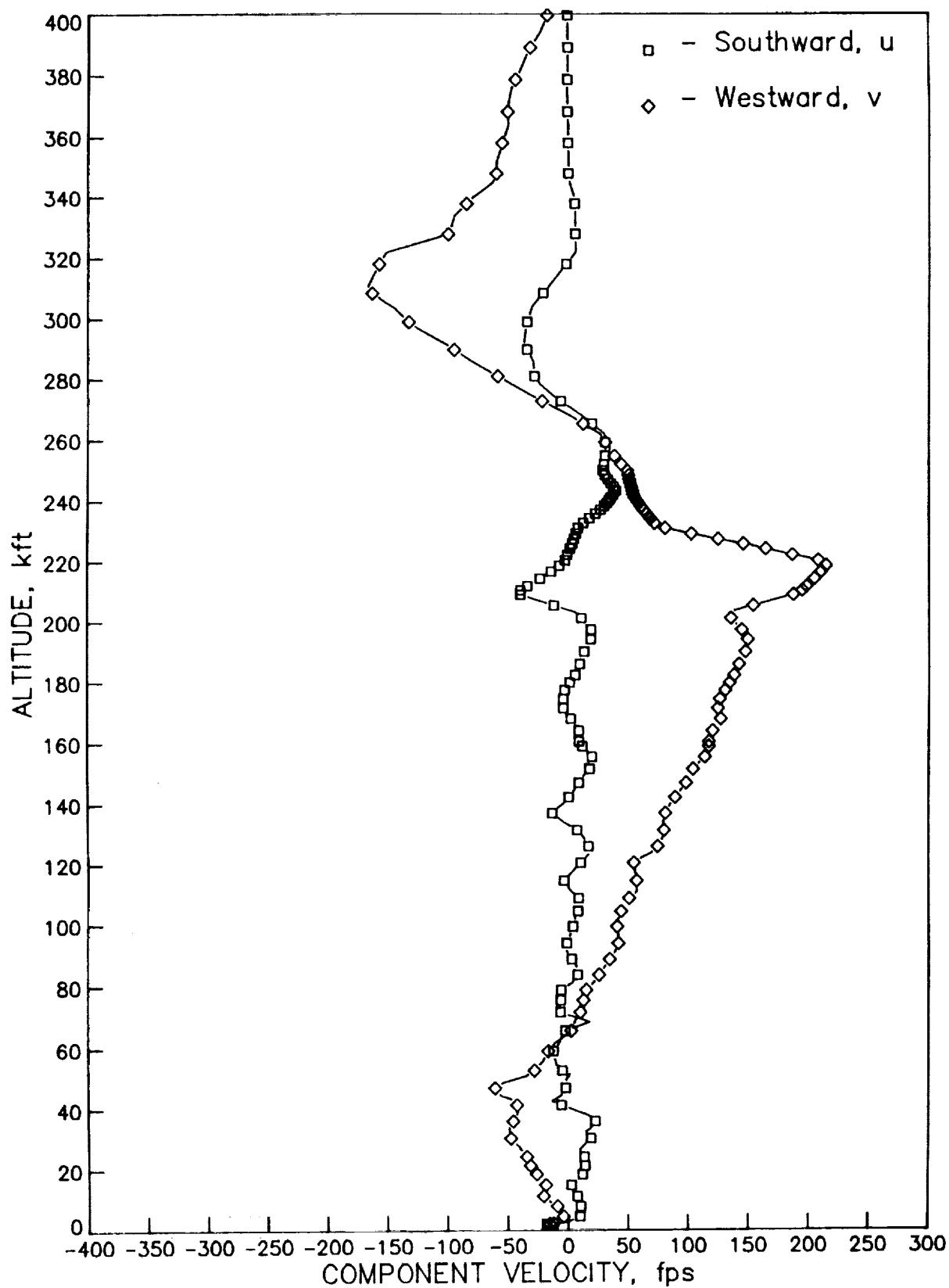


Figure II-4. Horizontal wind components versus altitude for STS-40.

June 14, 1991

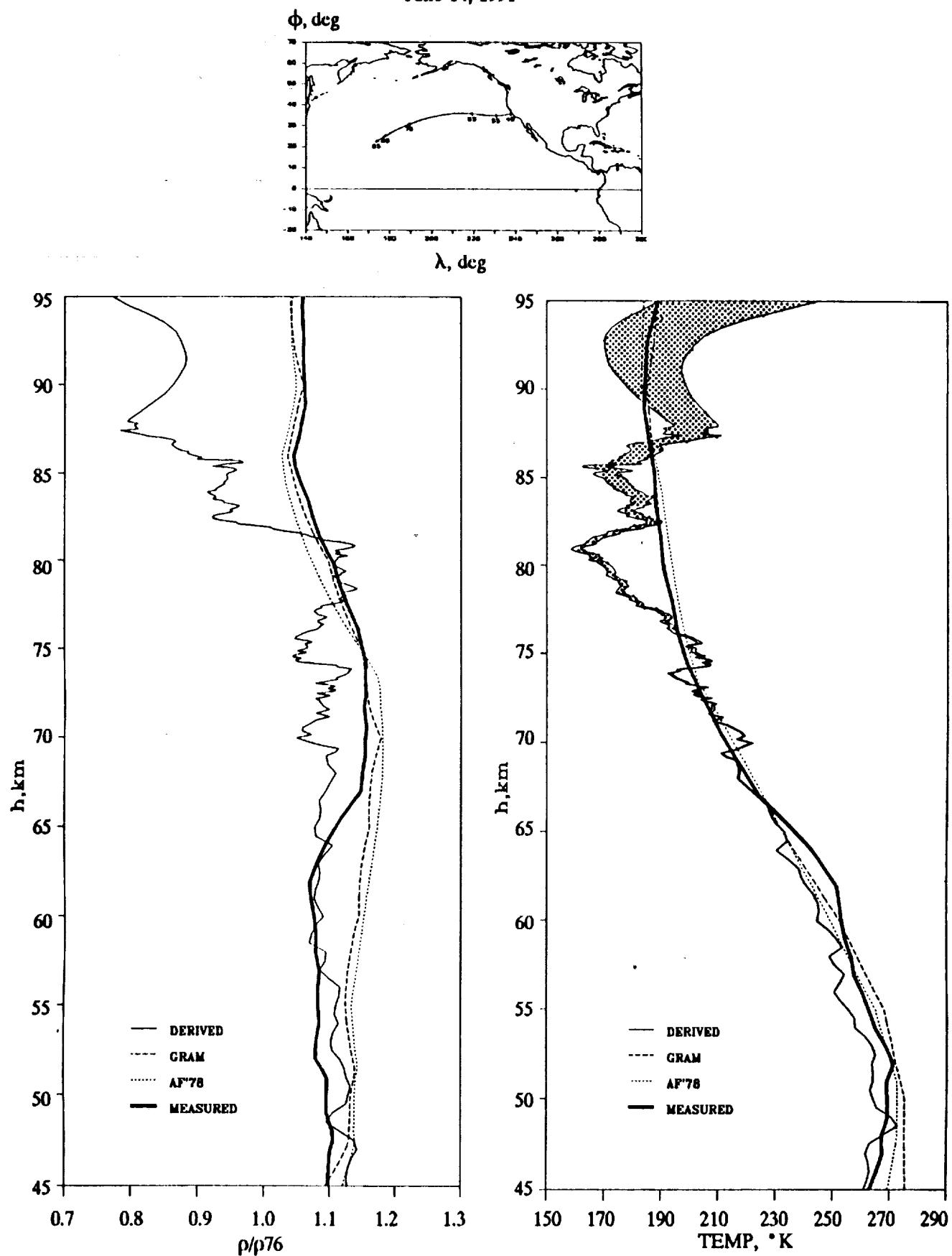


Figure II-5. STS-40 density and temperature comparisons.

III. AERODYNAMIC BET DEVELOPMENT AND SUMMARY RESULTS

The available 218-word AEROBET for STS-40 is ABETF40/UN=254885C, a direct access file on the LaRC CDC machines. This product was developed based on the previously discussed Extended BET, the recorded configuration data, the final mass properties of the Orbiter, and, of course, the Shuttle aerodynamic databook (final pre-operational L7 version rectified using the FAD26). Perusal of Reference 1 (Part IV) is recommended for those desiring additional information concerning the development and contents of this file.

The final mass properties were obtained via JSC and are presented herein as Table 7. These data were usurped from an abbreviated post-flight report. Configuration data required are the onboard measurements of the control surface deflections and RCS jet activity which, for this flight, were obtained from OI-2 reel NB0387. This is a 25 Hz file which must be synched to the times on the BET. The OI-2 data for this flight were much cleaner than observed on many of the past missions. The only selective editing required was to replace the right outboard elevon panel data, which were bad records, with the data from the right inboard channel. This replacement is of minimal consequence since both panels should be essentially equal throughout.

Summary results showing configuration and aerodynamic performance comparisons for STS-40 are next presented. For that purpose, the results will be plotted versus Mach number. Mach number is generally the variable of interest to aerodynamic investigators but readers should note that the databook formulation incorporates table look-ups versus alternate variables, to include altitude, VBAR, and Mach number dependent upon the particular flight regime.

Figures III-1 and III-2 are a replot of the Shuttle angular rates and linear accelerations shown in an earlier subsection of this report, though plotted here versus Mach number. Control surface deflections are next presented versus Mach number as Figure III-3. As such, a measure of comparison versus the range of control deflections exercised on the first twenty-two flights can be graphically obtained. The shaded band indicates the previous range flown over that earlier ensemble of flights, up to and including STS 61-C, the first OEX mission. Though of interest, the shaded region shown on this and other plots may no longer reflect the current range of control effectors since the band has not been updated for some time.

Figure III-4 presents the flight center-of-gravity plotted against Mach number. Again, the range associated with the earlier 22 flights is noted by the shaded region. As can be seen, the STS-40 c.g. is somewhat outside the implied boundary from the previous subset of flights.

Next, the air-relative attitude angles are shown versus Mach number (refer to Figure III-5). Once again the angle-of-attack can be compared with excursions based on the previous 22-flight subset. The final summary results presented are typically of most interest to investigators. These are the longitudinal aerodynamic performance comparisons. Aerodynamic differences are presented as a percentage of the flight-derived coefficient. The differences are defined as flight-extracted minus predicted values, where the predicted values have been rectified pursuant to the FAD26 incrementals. Lift, drag, and L/D comparisons are shown in Figure III-6. Axial force, normal force, and pitching moment coefficient comparisons are presented in Figure III-7. The pitching moment comparisons are made at the 65 percent moment reference center consistent with the databook. The shaded bands superimposed on these figures indicate the statistically expected aerodynamic comparison accuracy. Though these statistics are also computed based on the 22-flight subset, as statistical uncertainties these data should still be representative. To that extent, the pitching moment discrepancies still remain outside the expected band throughout the hypersonic regime.

Event	Time	Weight (pounds)	Center-of-gravity (inches in OSRS)		
			X	Y	Z
Post deorbit	-1078	228677.2	1079.5	-0.2	372.0
Entry Interface	565	227709.2	1081.1	-0.2	371.9
EI + 3 minutes	745	227602.2	1080.5	-0.2	371.8
Mach 3	2049	226737.2	1079.6	-0.2	371.4
Gear deploy	2428	226535.2	1080.9	-0.2	369.0

Event	Time	Moments and products of inertia slug ft ²					
		I _{xx}	I _{yy}	I _{zz}	I _{xy}	I _{xz}	I _{yz}
Post deorbit	-1078	953310	7355576	7642294	-67	170326	1109
Entry Interface	565	956558	7281076	7567322	-154	169147	697
EI + 3 minutes	745	954584	7259706	7547369	-139	163512	685
Mach 3	2049	951582	7243820	7531778	-139	159047	622
Gear deploy	2428	980573	7264850	7528218	-55	150950	596

Times referenced from epoch, 53904 sec (GMT) on June 14, 1991.

Table 7. STS-40 final mass properties.

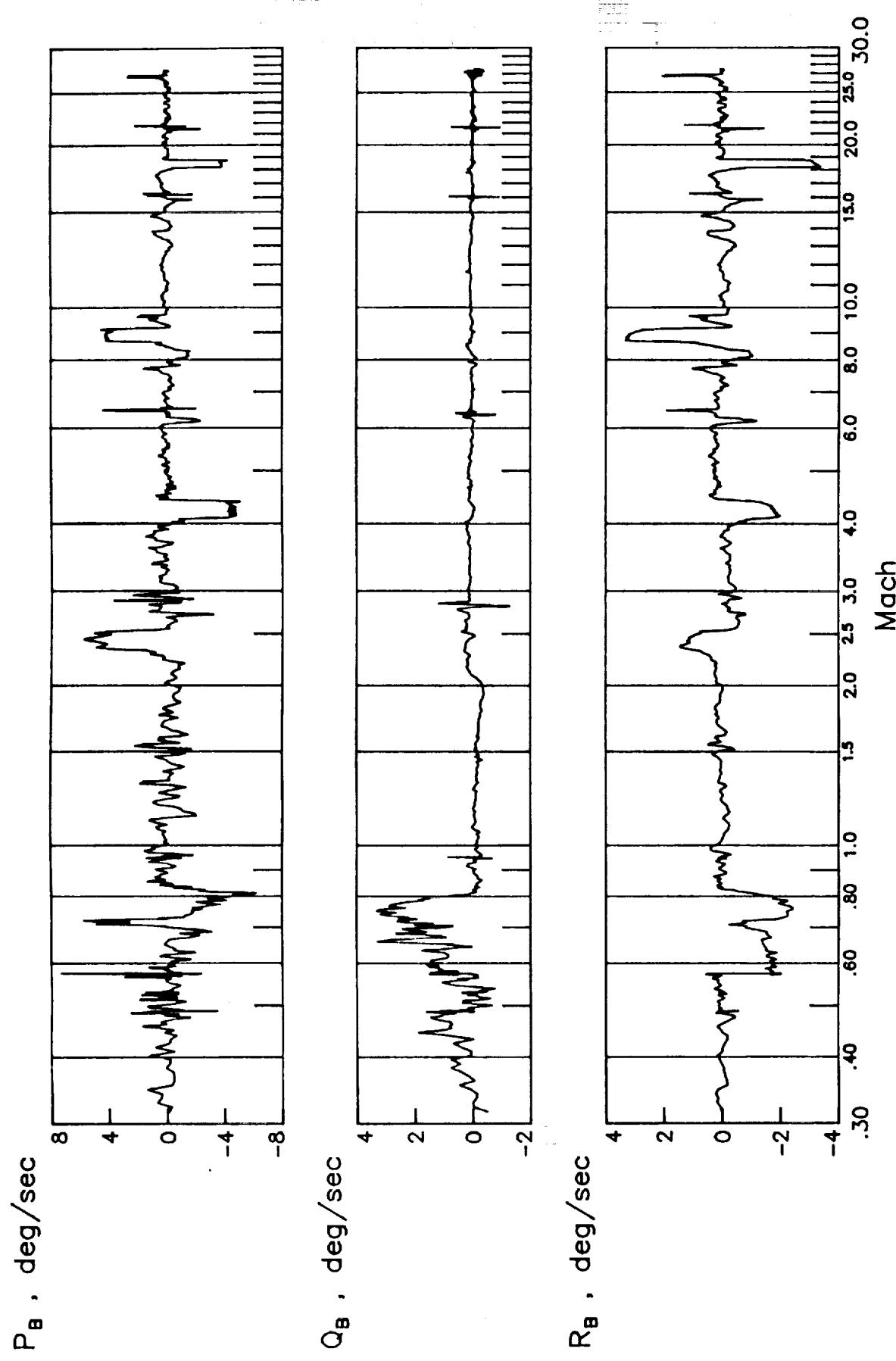


Figure III-1. STS-40 angular rates versus Mach number.

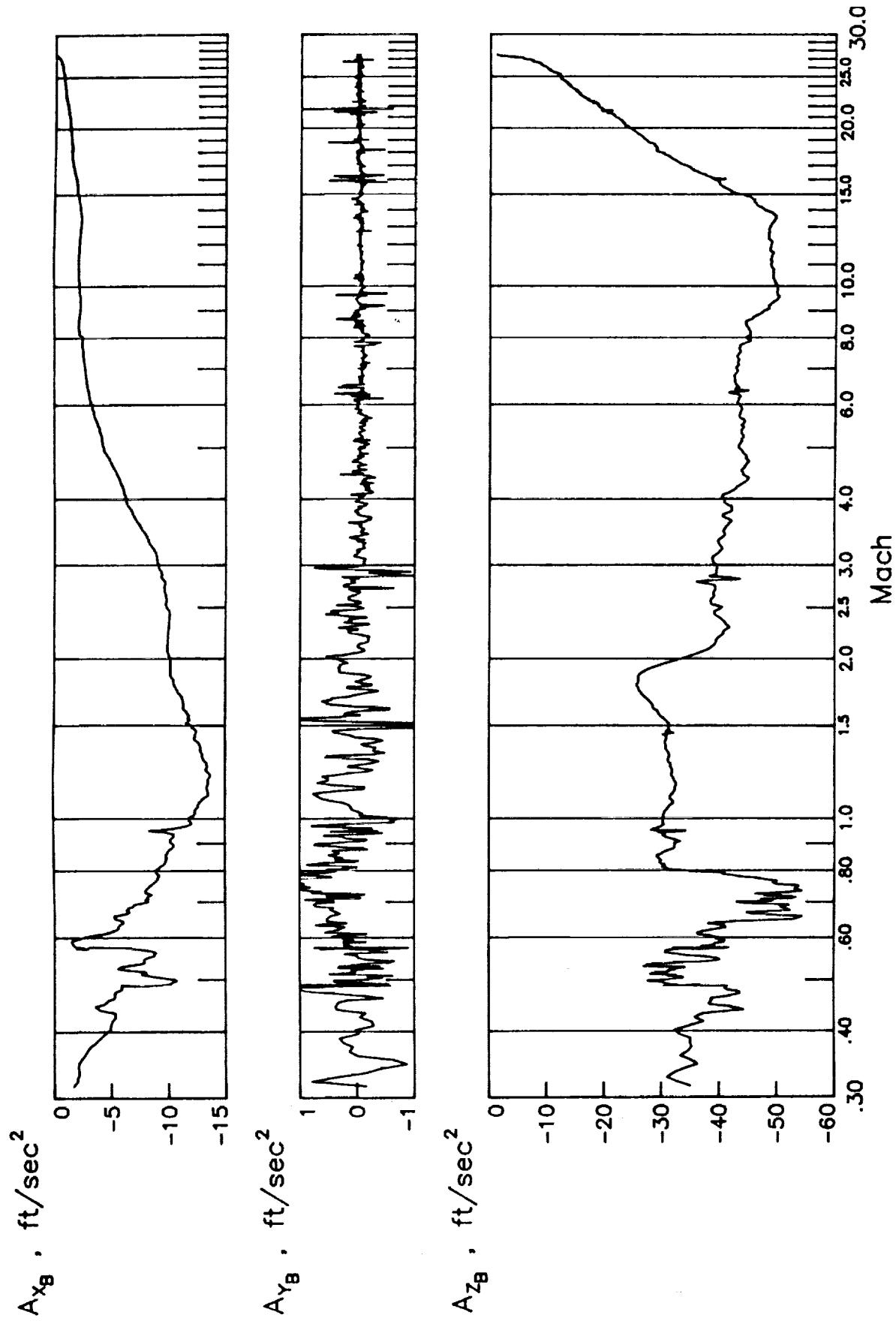


Figure III-2. STS-40 accelerations versus Mach number.

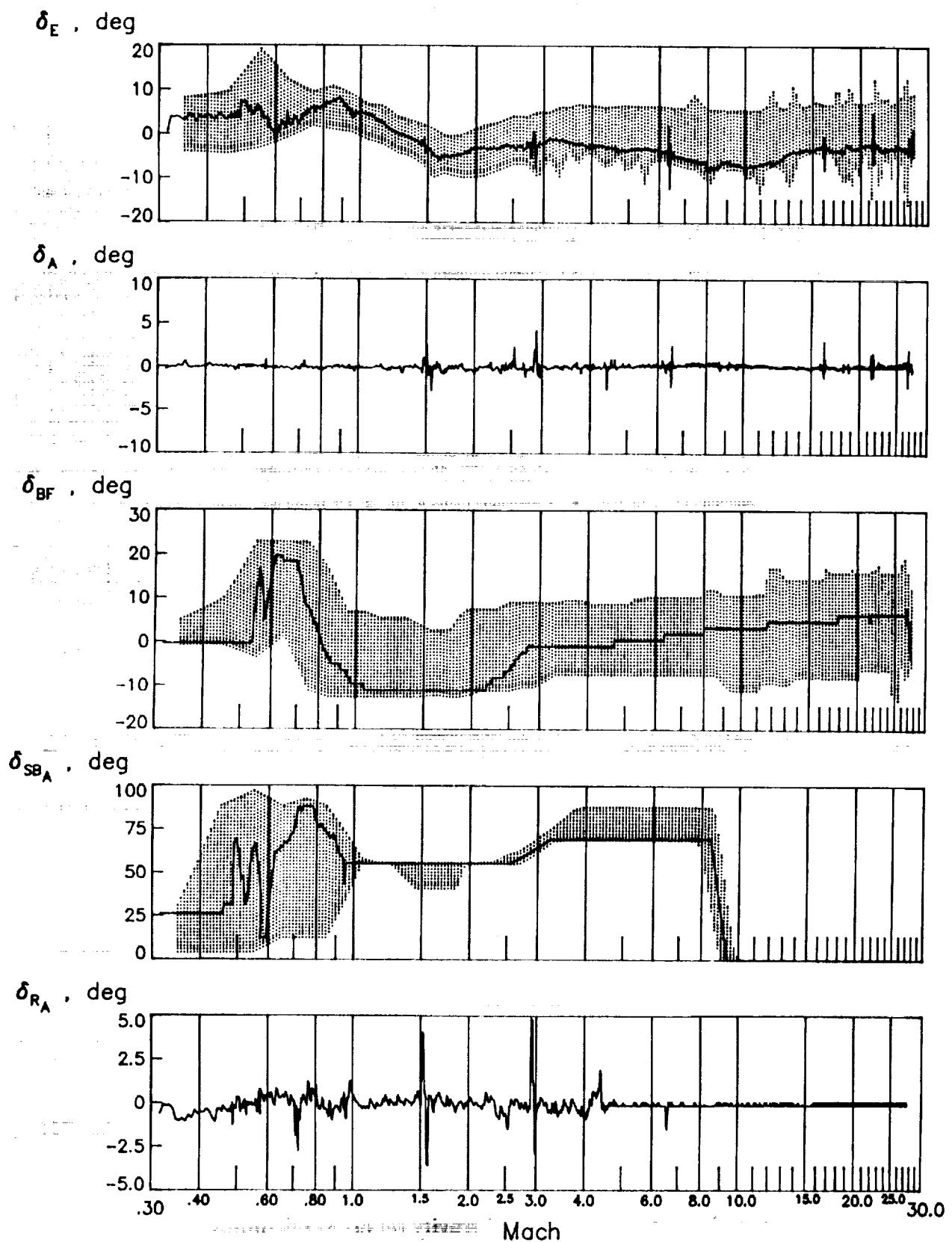


Figure III-3. STS-40 control surface deflections versus Mach number.

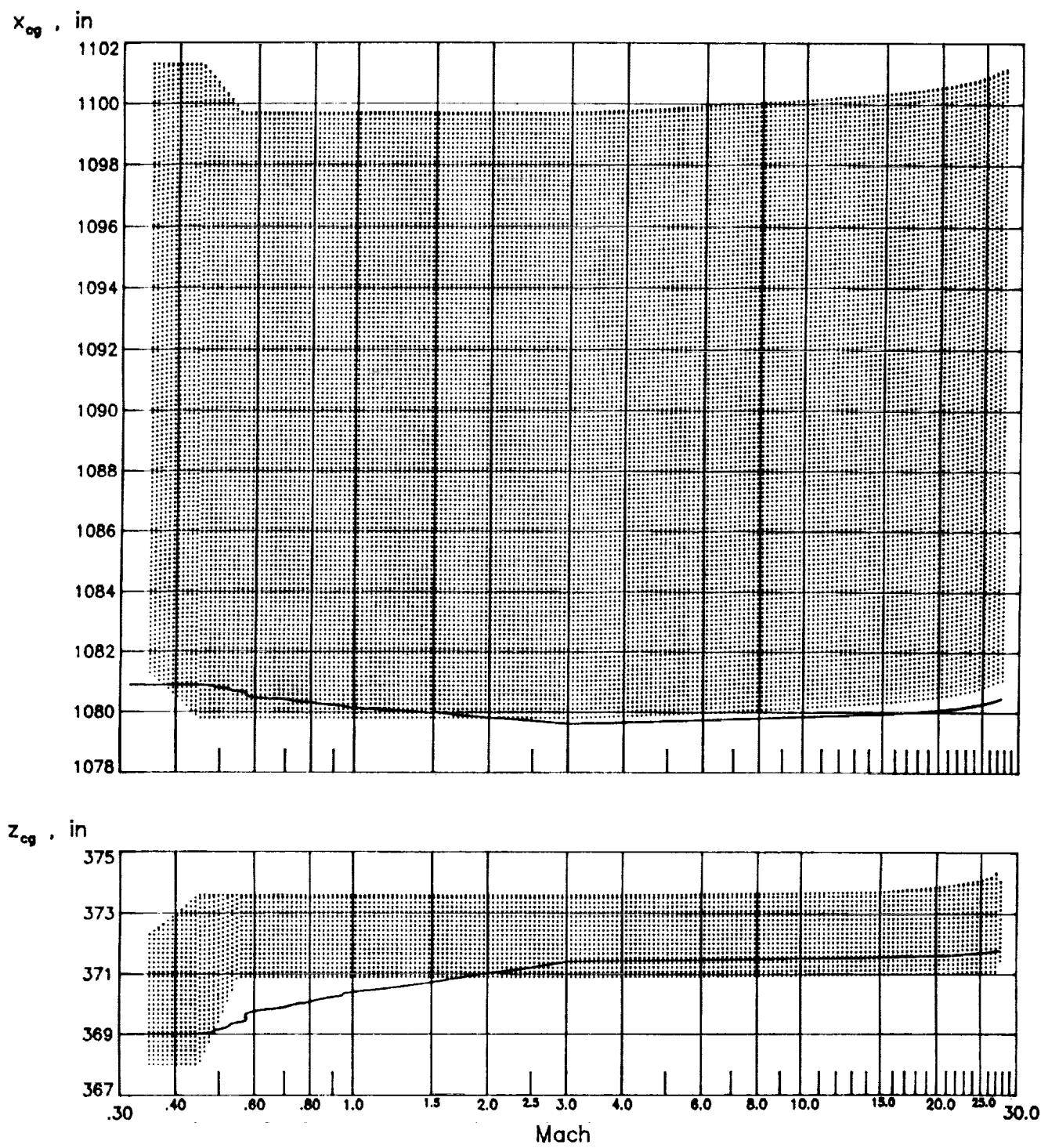


Figure III-4. STS-40 center-of-gravity versus Mach number.

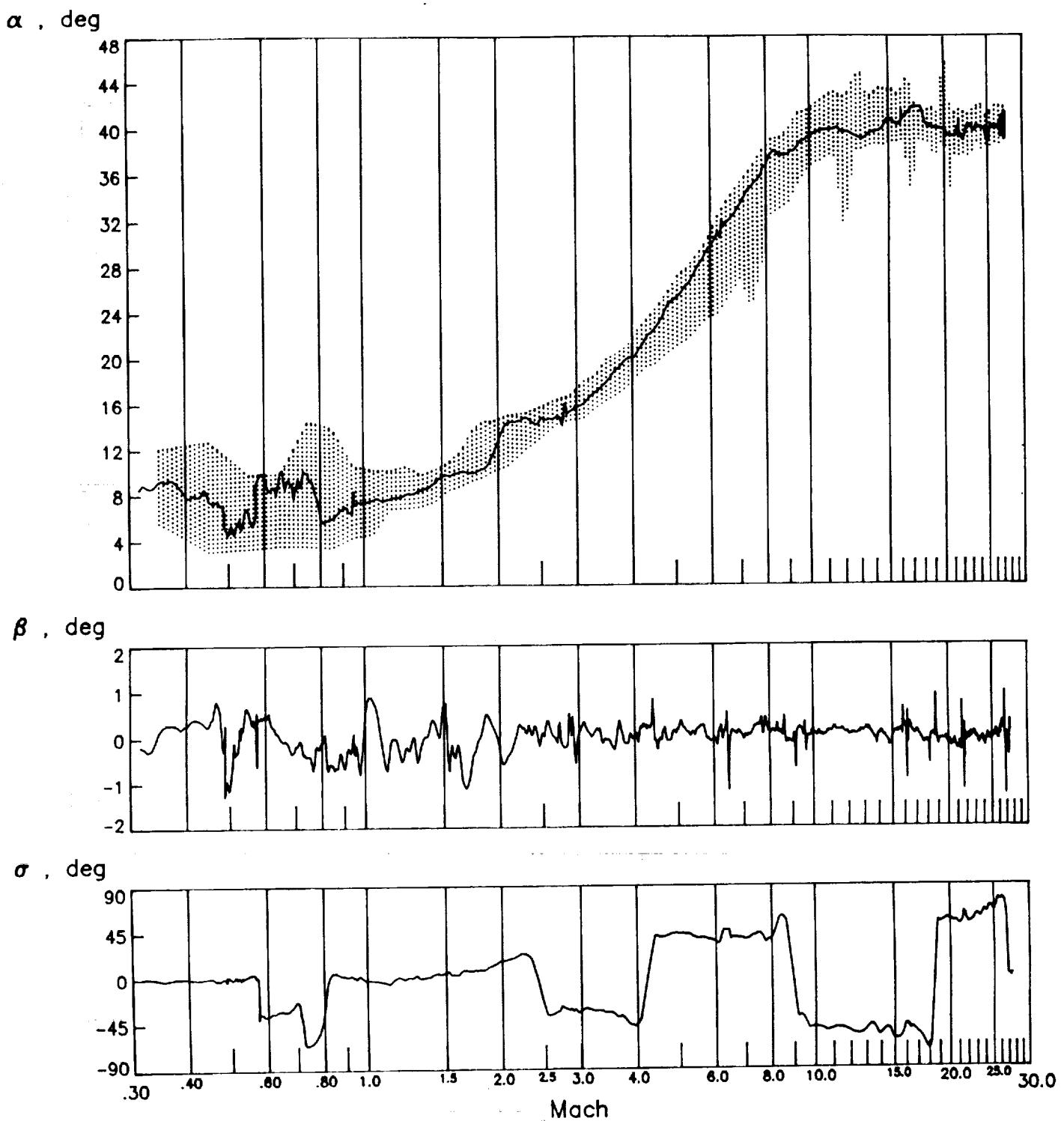
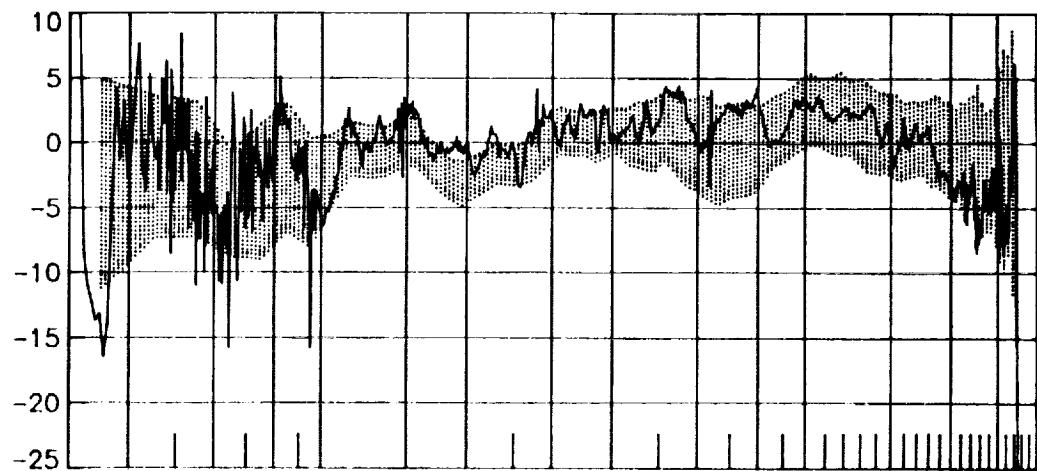
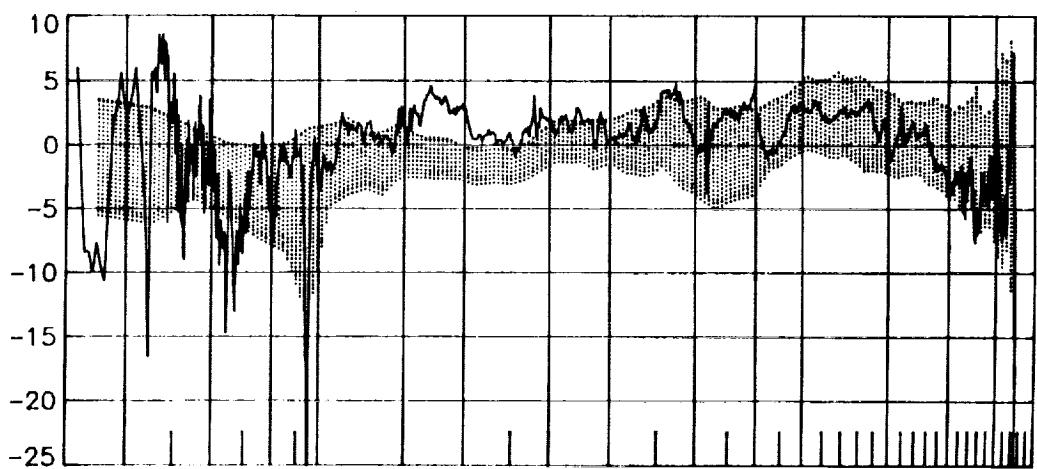


Figure III-5. STS-40 air-relative attitude angles versus Mach number.

ΔC_L , percent



ΔC_D , percent



$\Delta(L/D)$, percent

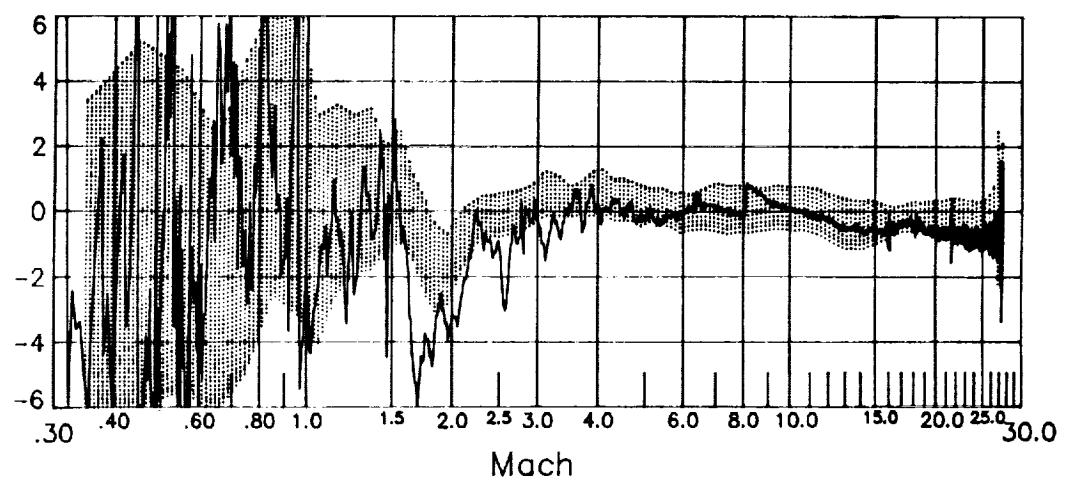
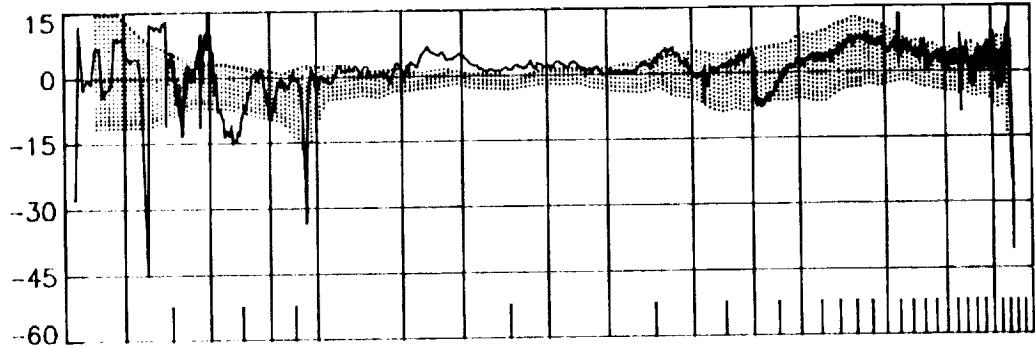
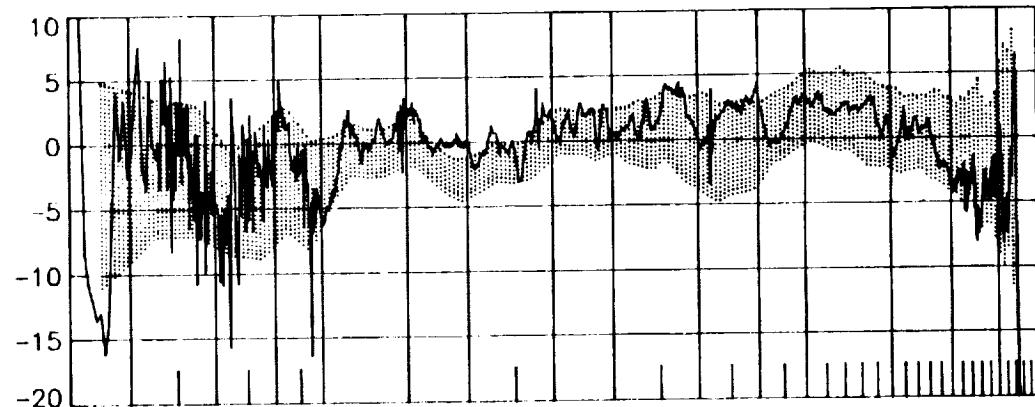


Figure III-6. STS-40 flight/databook lift, drag and L/D comparisons for which the predicted values are rectified by the FAD26 incrementals.

ΔC_A , percent



ΔC_N , percent



ΔC_m , percent

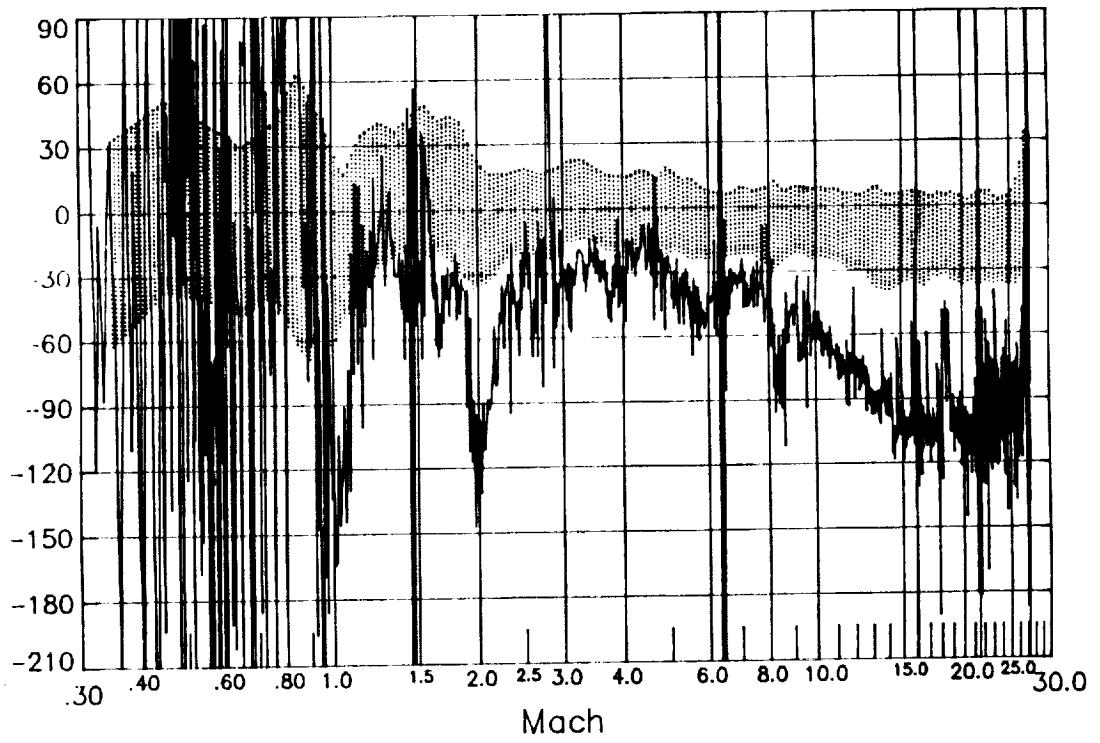


Figure III-7. STS-40 axial force, normal force and pitching moment comparisons.
(databook rectified by FAD26, C_m referenced to 65% X/L)

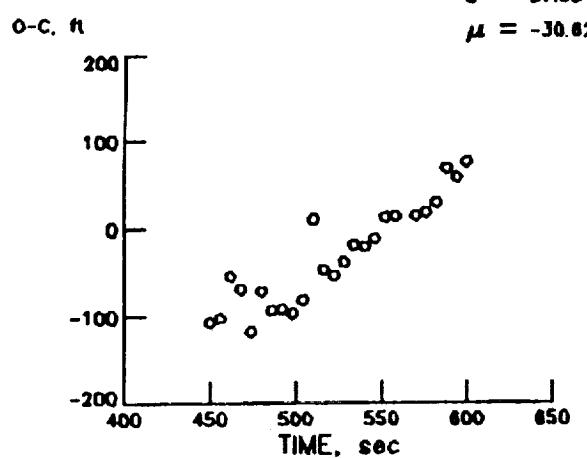
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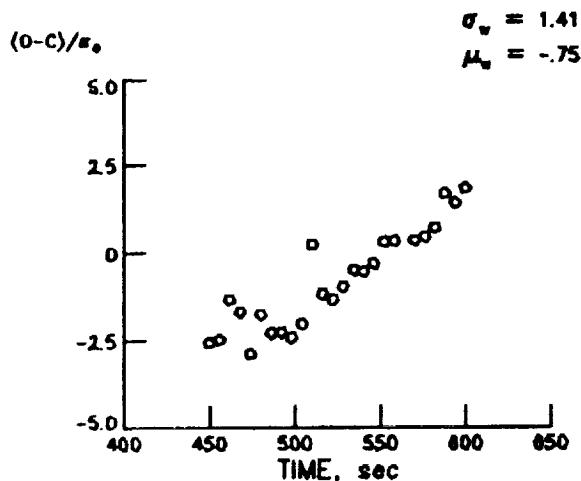
APPENDIX A

FINAL C-BAND RADAR AND CINETHEODOLITE RESIDUALS FOR STS-40 BET DETERMINATION

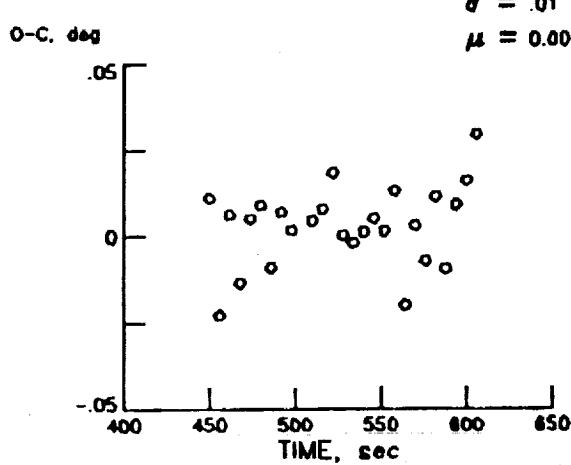
RESIDUALS



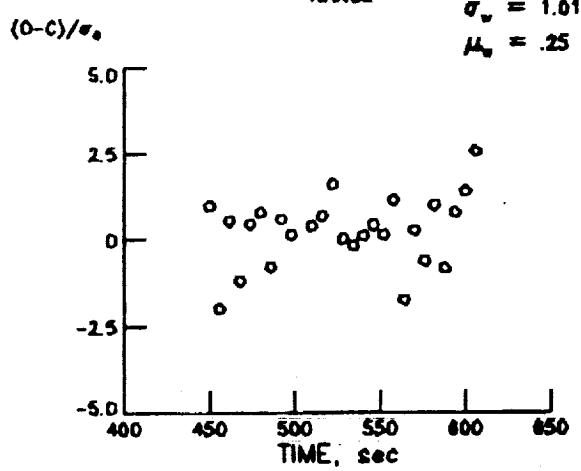
WEIGHTED RESIDUALS



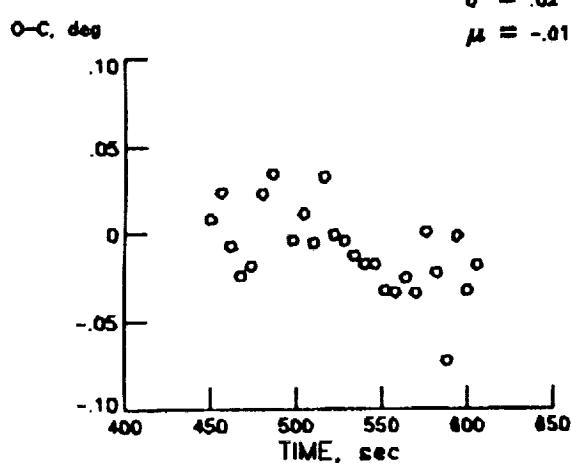
RANGE



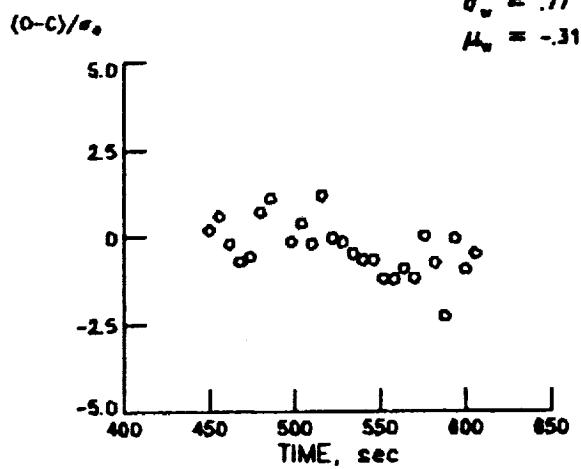
RANGE



AZIMUTH



AZIMUTH



ELEVATION

ELEVATION

Figure A-1. Final residuals for low-rate Kwajalein pass from KMTC.

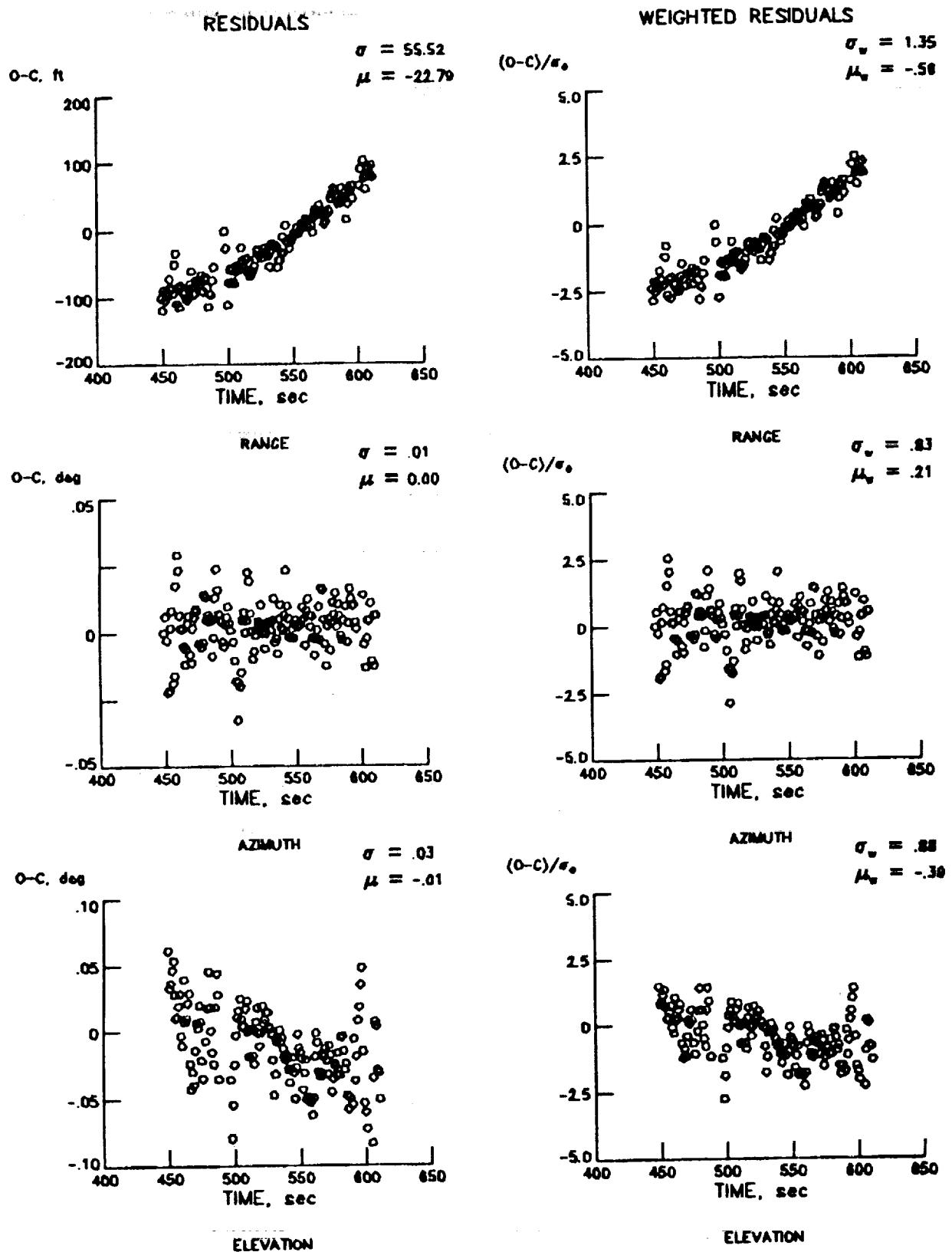


Figure A-2. Final residuals for high-rate Kwajalein pass, KMTC.

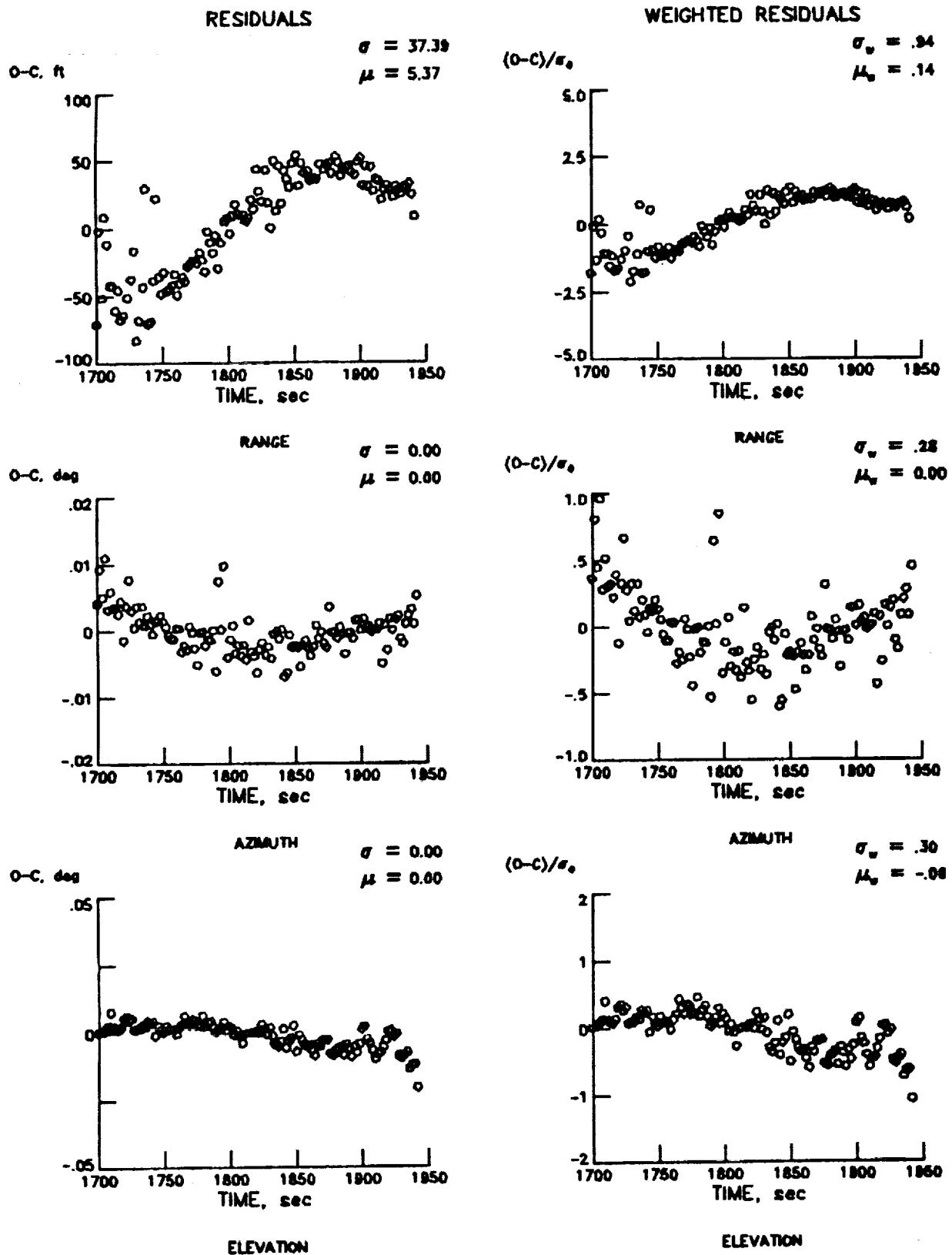
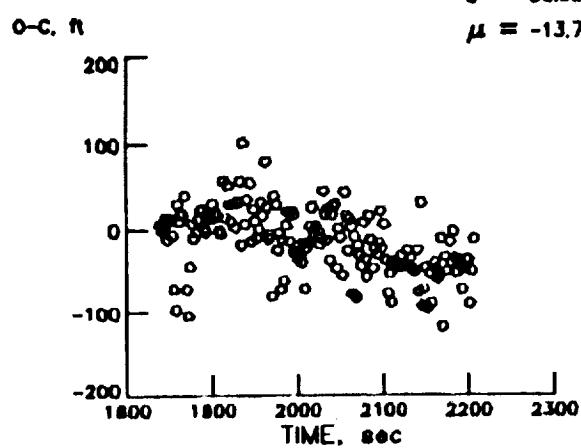
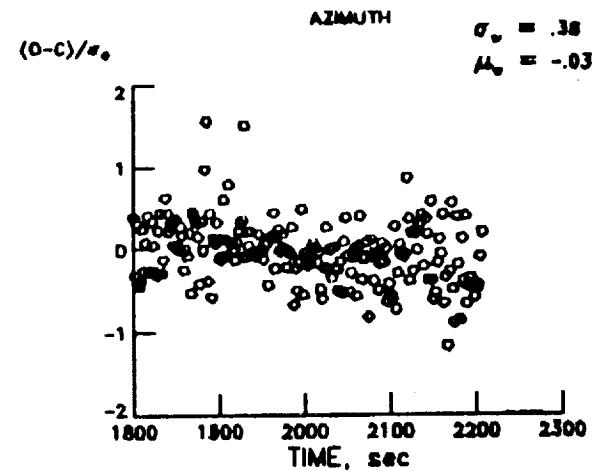
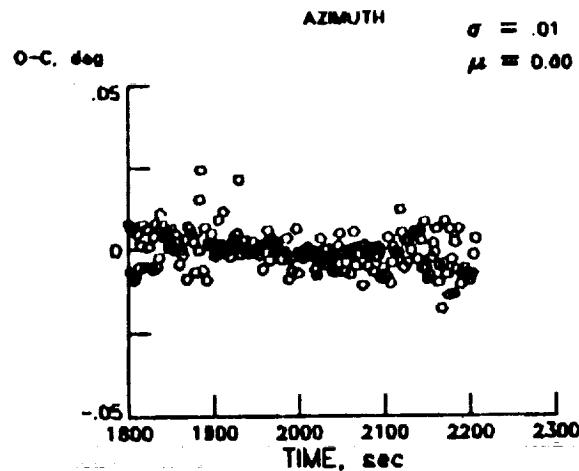
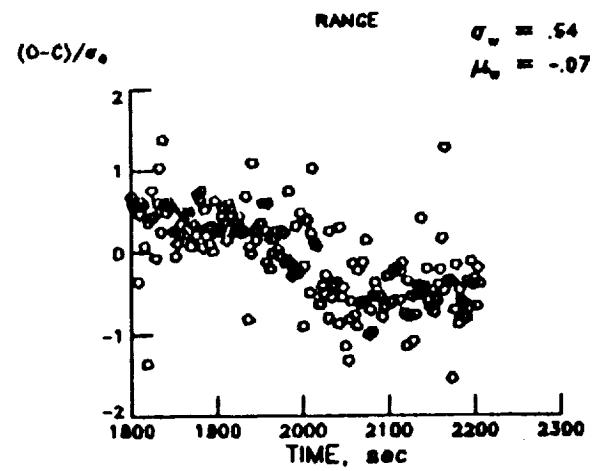
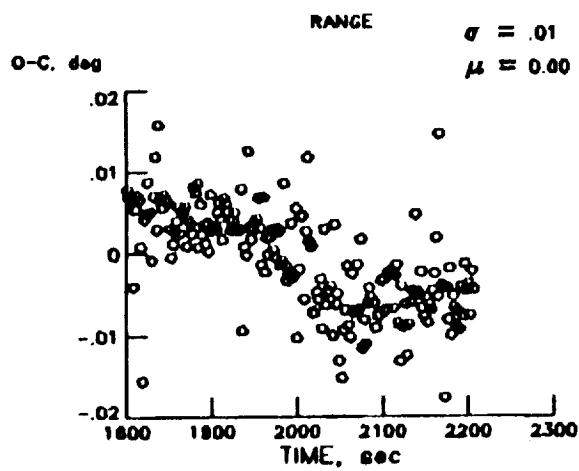
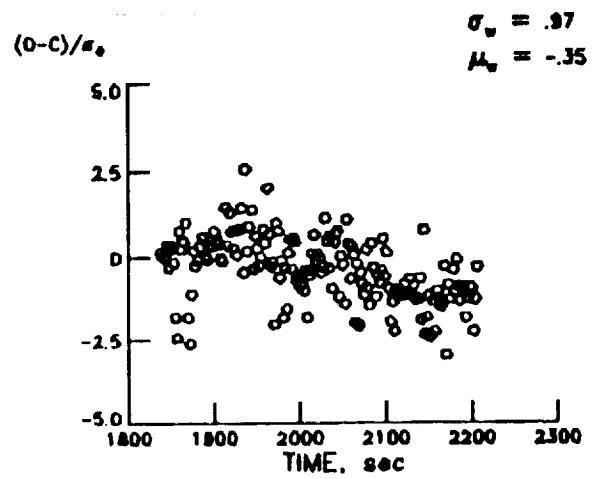


Figure A-3. Final residuals for Pt. Pillar, CA station, PTPC.

RESIDUALS



WEIGHTED RESIDUALS



ELEVATION

ELEVATION

Figure A-4. Final residuals for Pt. Mugu, CA station, PMFC.

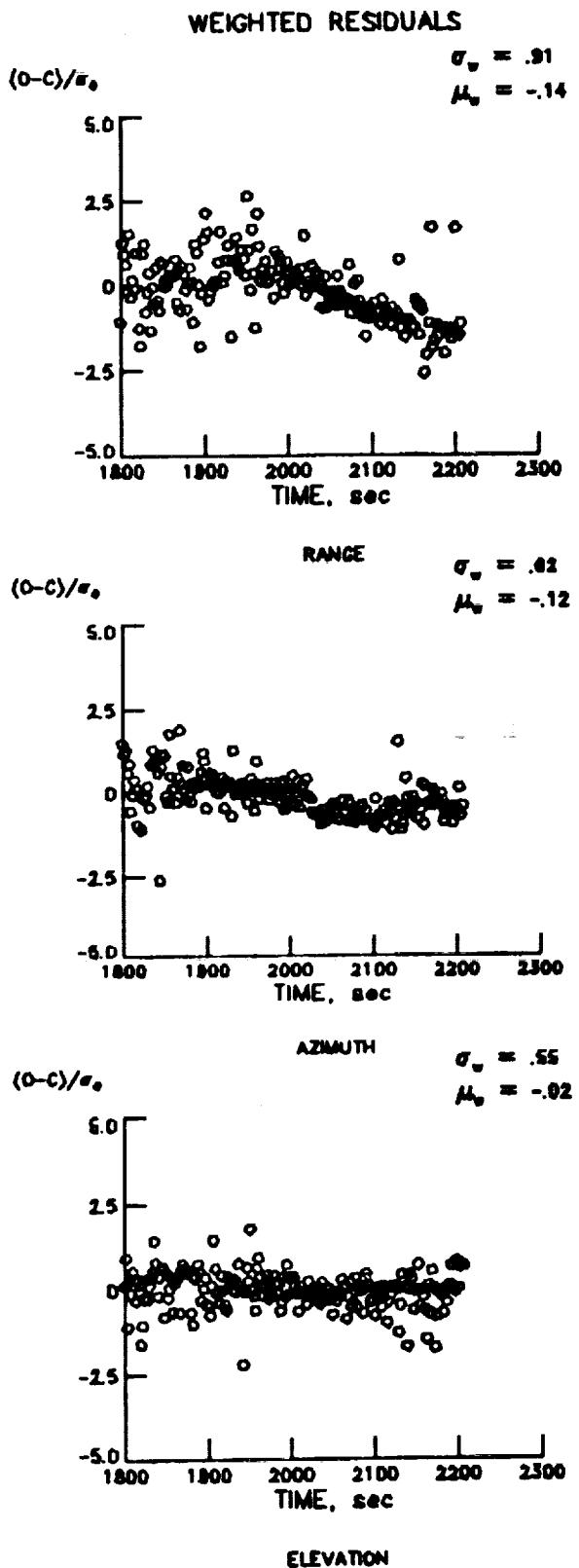
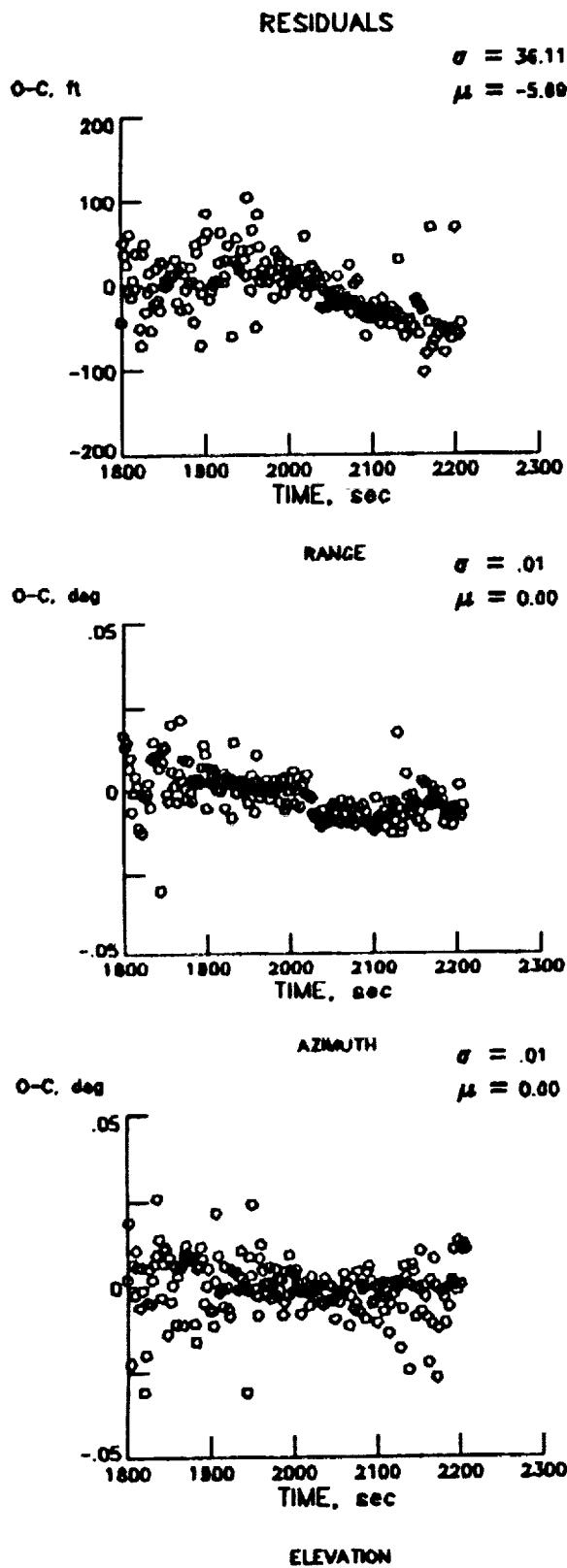
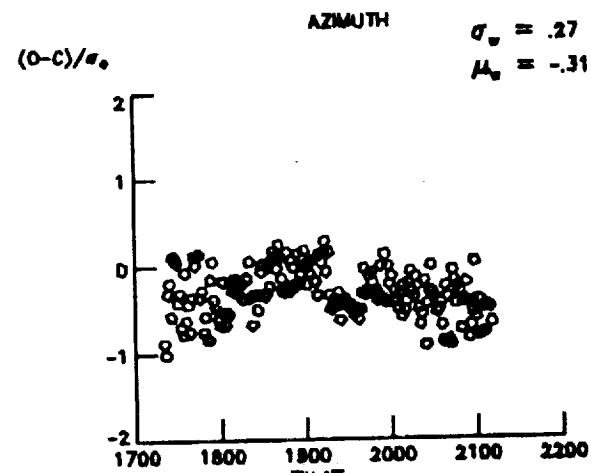
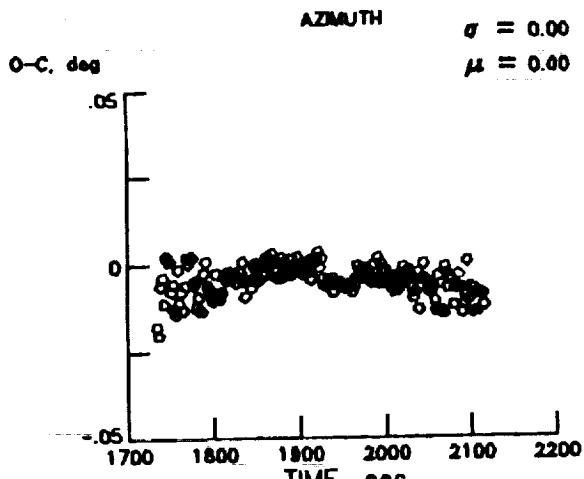
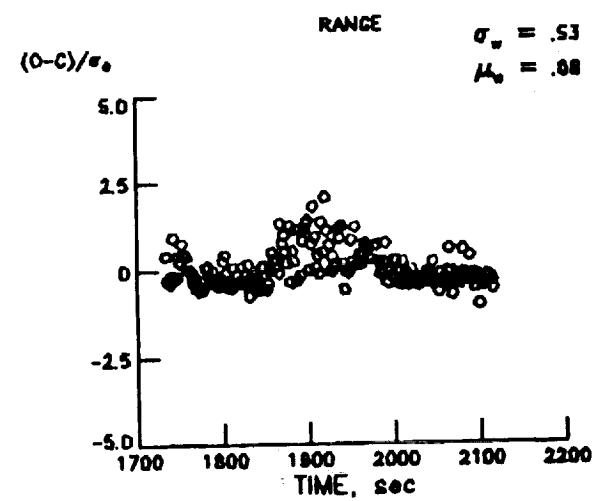
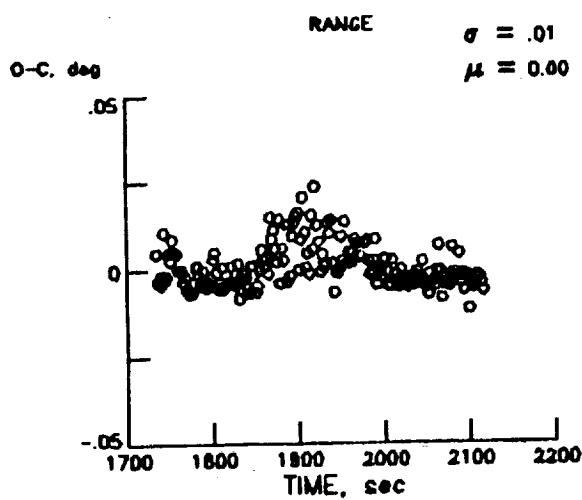
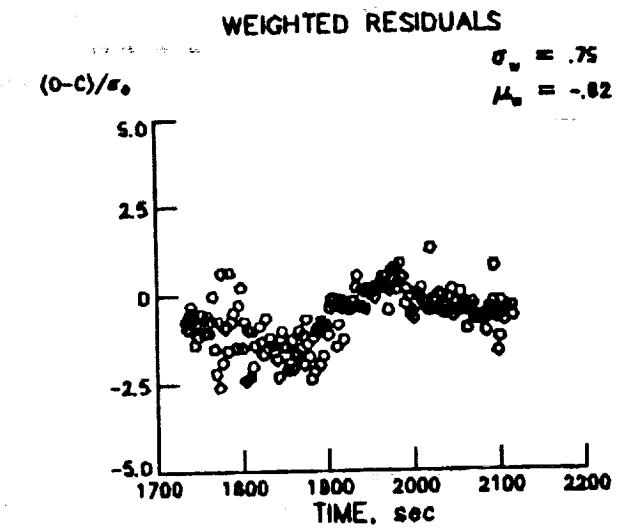
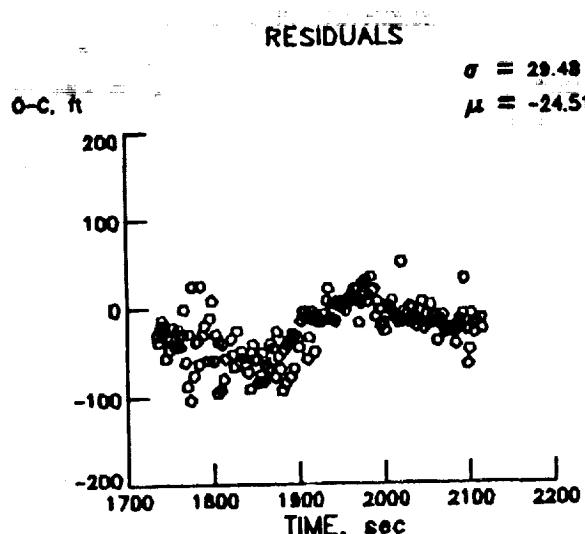


Figure A-5. Final residuals for Pt. Mugu, CA station, PMPC.



ELEVATION

ELEVATION

Figure A-6. Final residuals from Vandenberg station, VDBC.

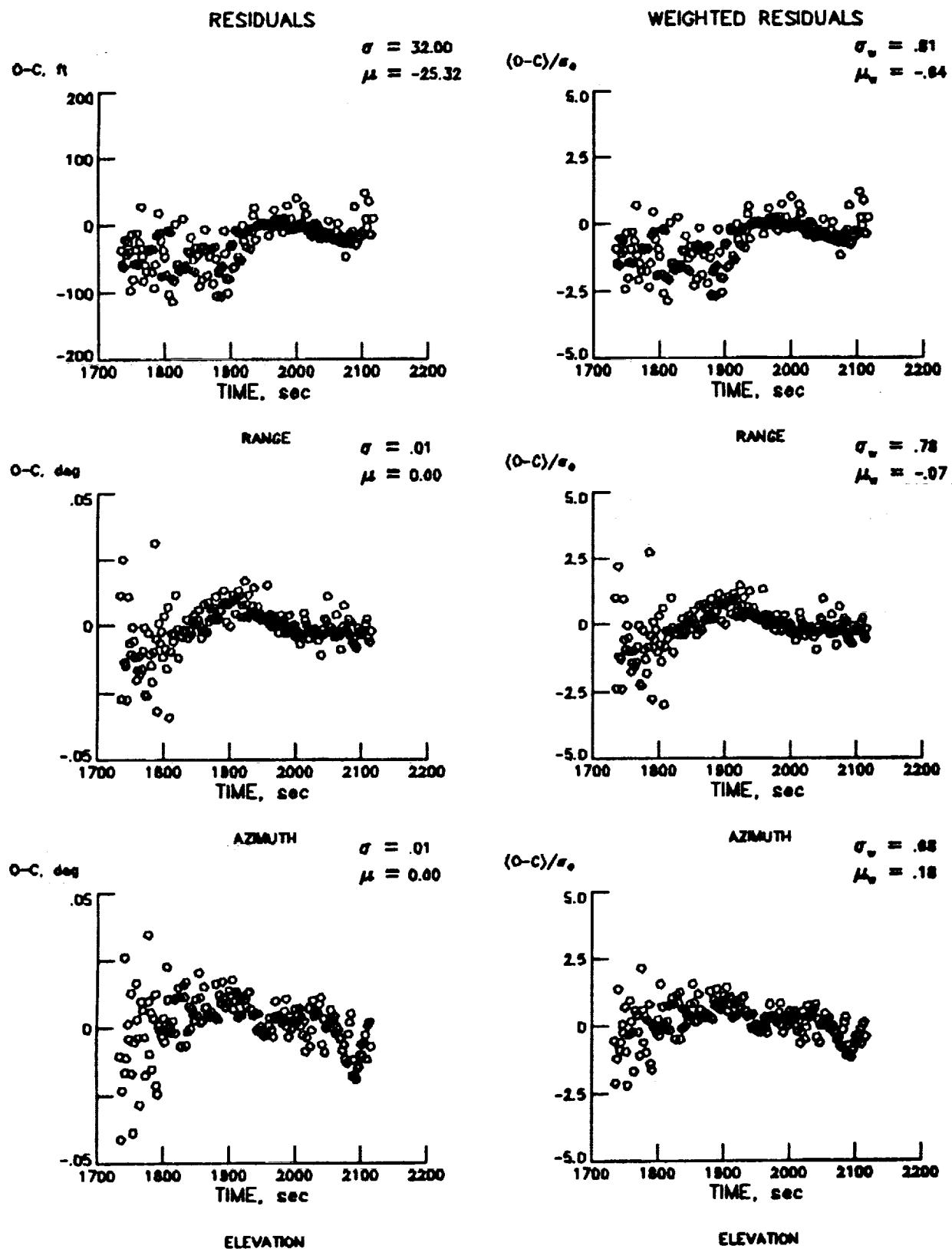


Figure A-7. Final residuals from Vandenberg station, VDFC.

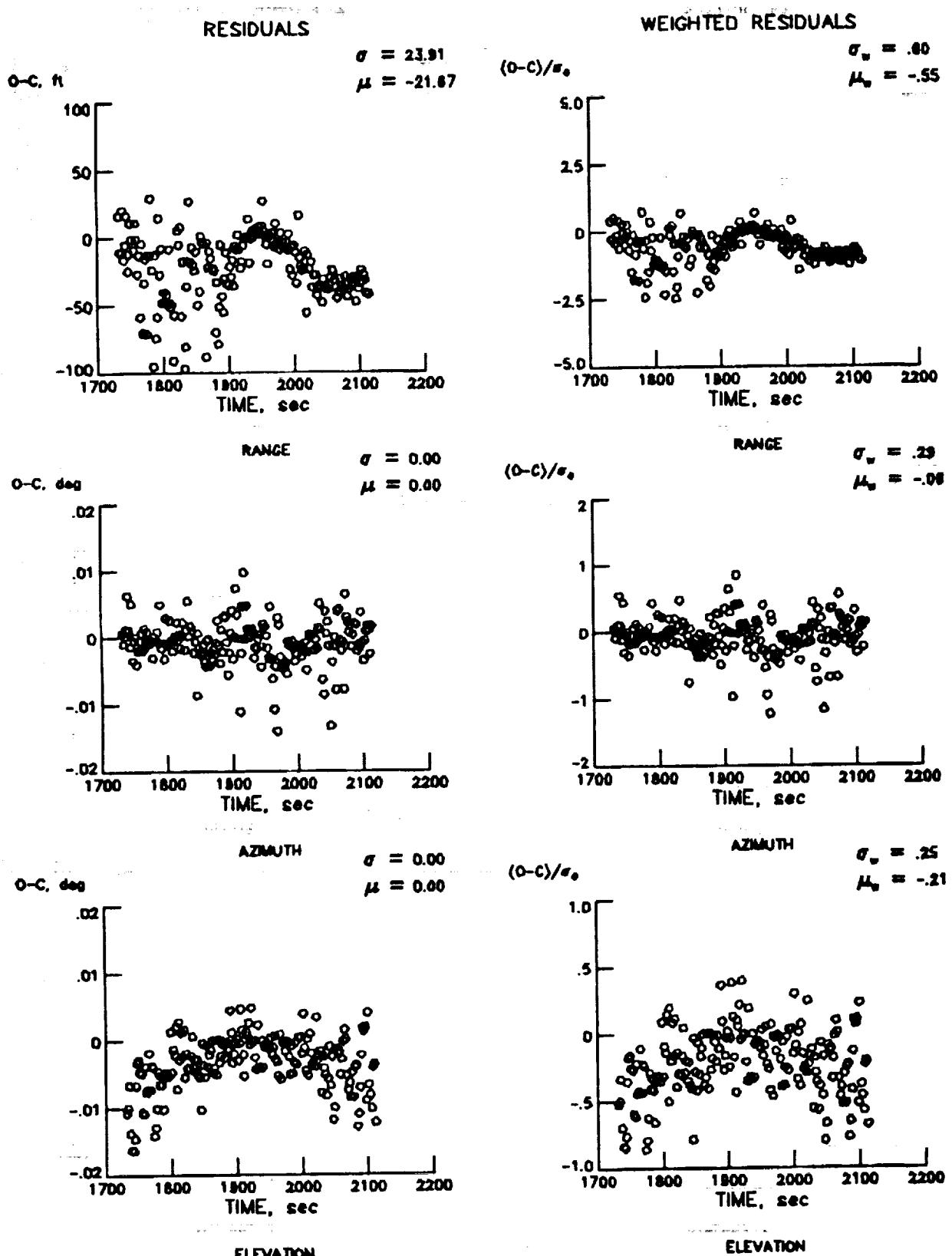
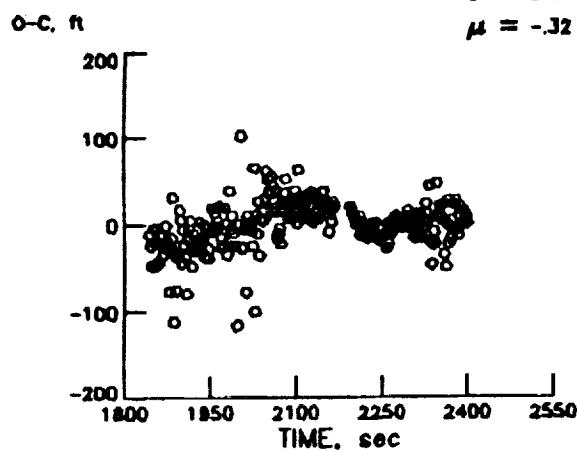
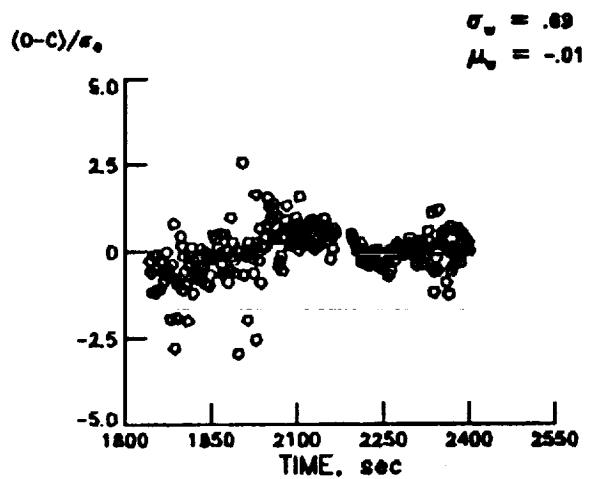


Figure A-8. Final Vandenberg residuals, VDHC.

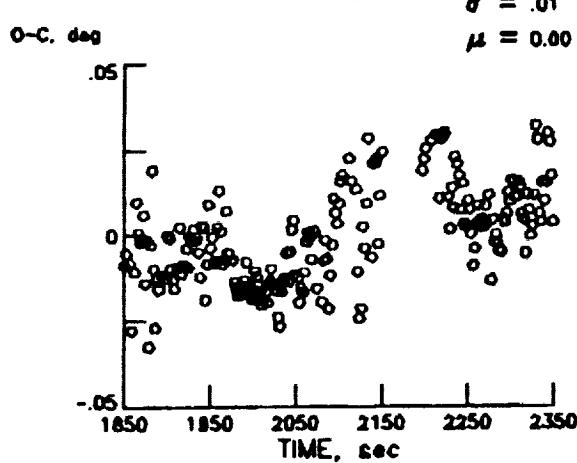
RESIDUALS



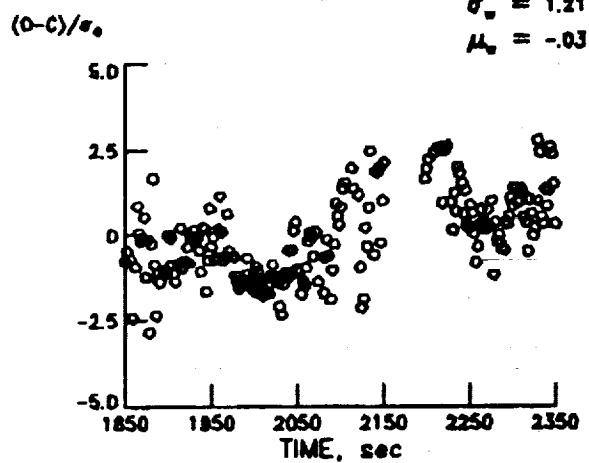
WEIGHTED RESIDUALS



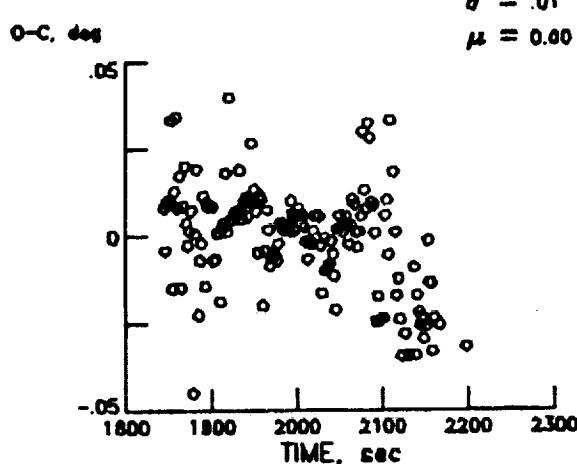
RANGE



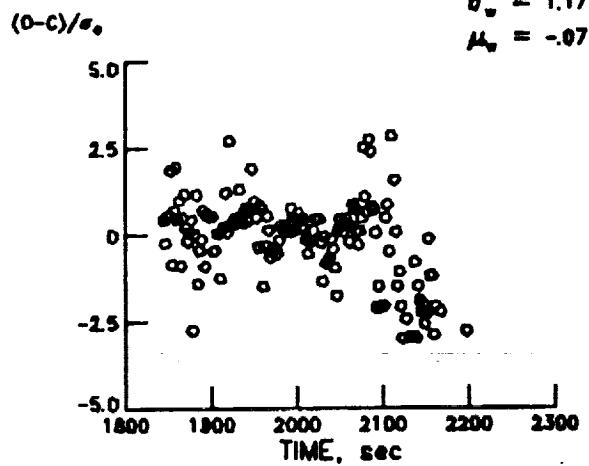
RANGE



AZIMUTH



AZIMUTH



ELEVATION

ELEVATION

Figure A-9. Final residuals from EAEB station, EFFC.

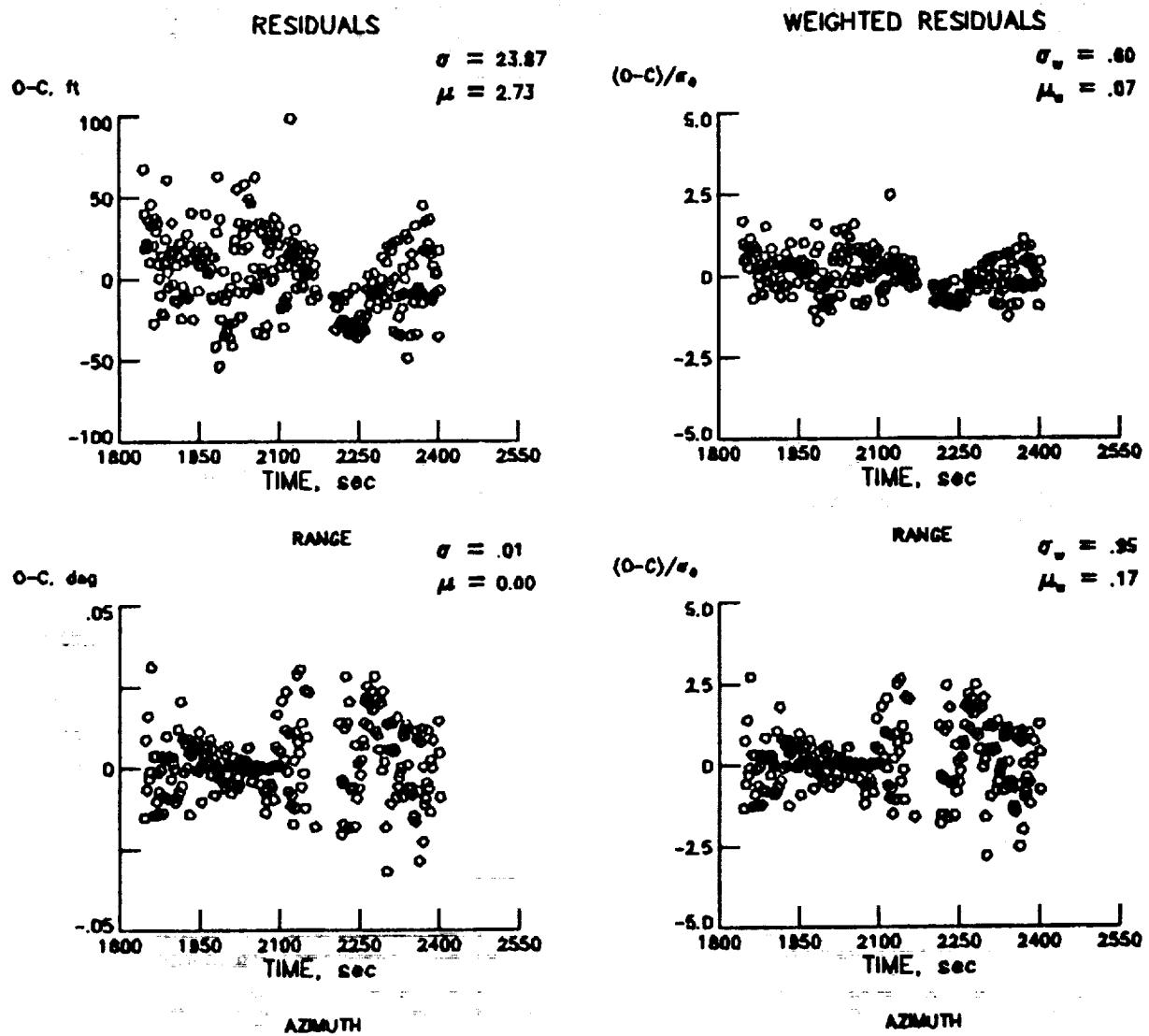


Figure A-10. Final residuals from DFRF station, FRCC.

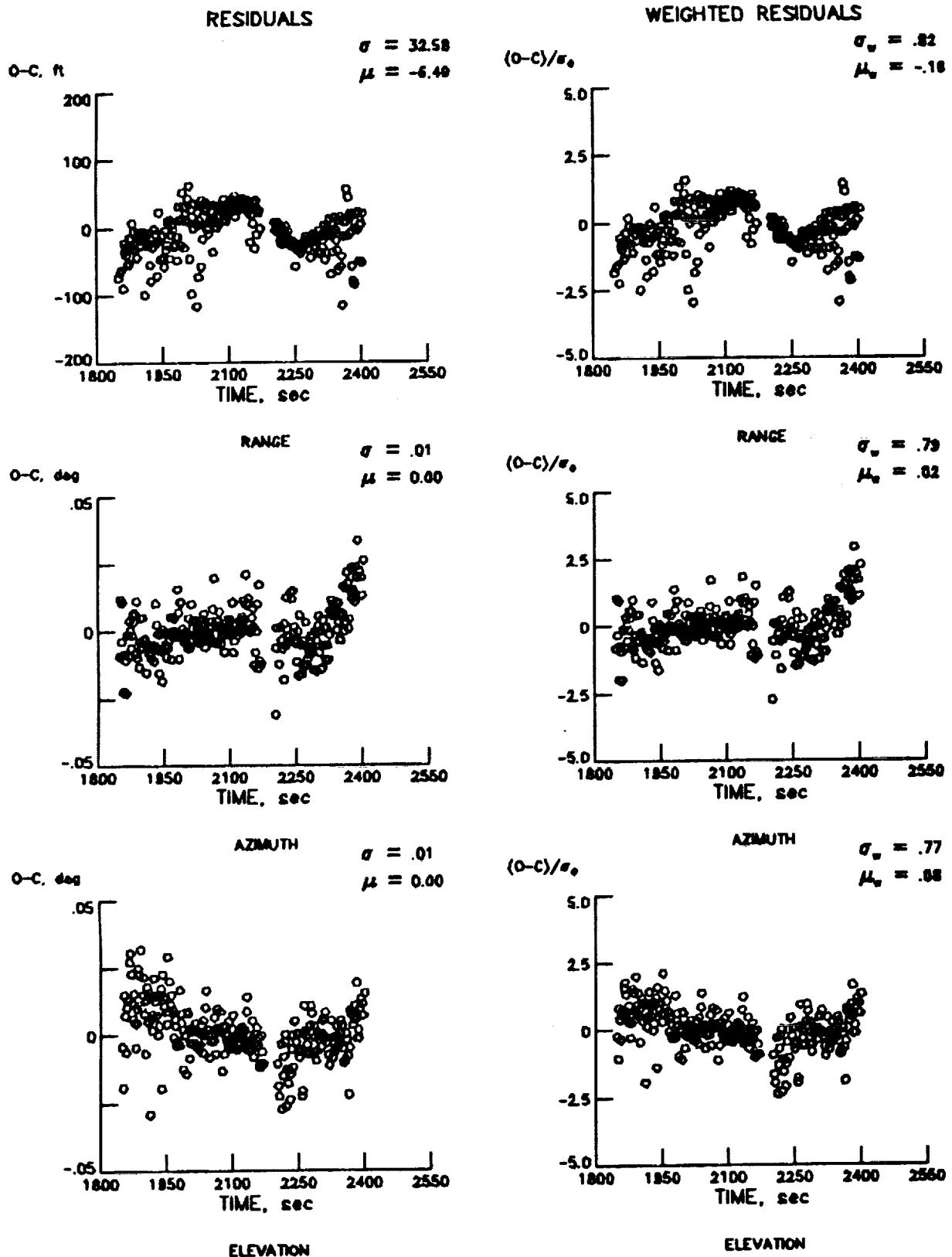


Figure A-11. Final Dryden residuals, FRFC.

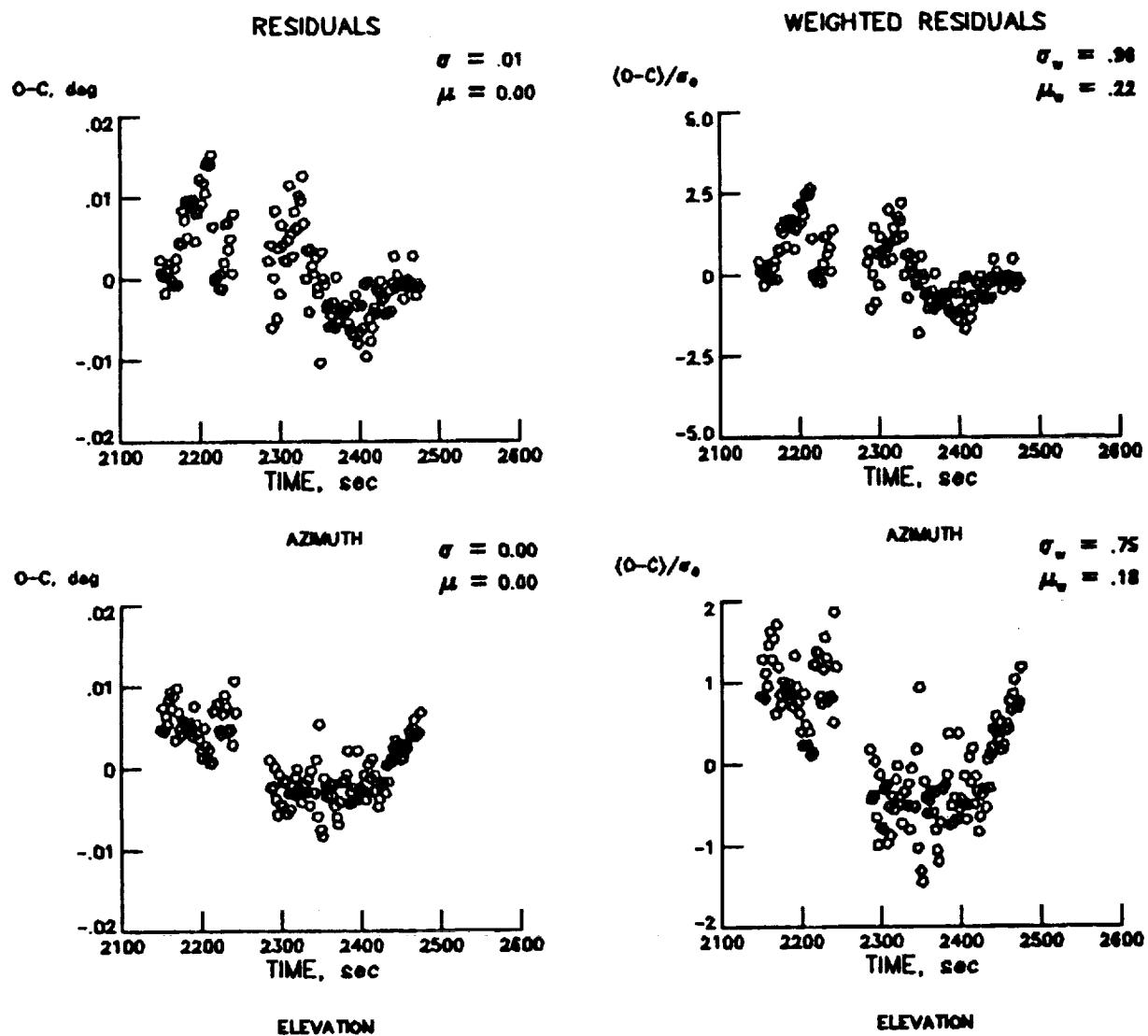


Figure A-12. Final cinetheodolite residuals from THEO1.

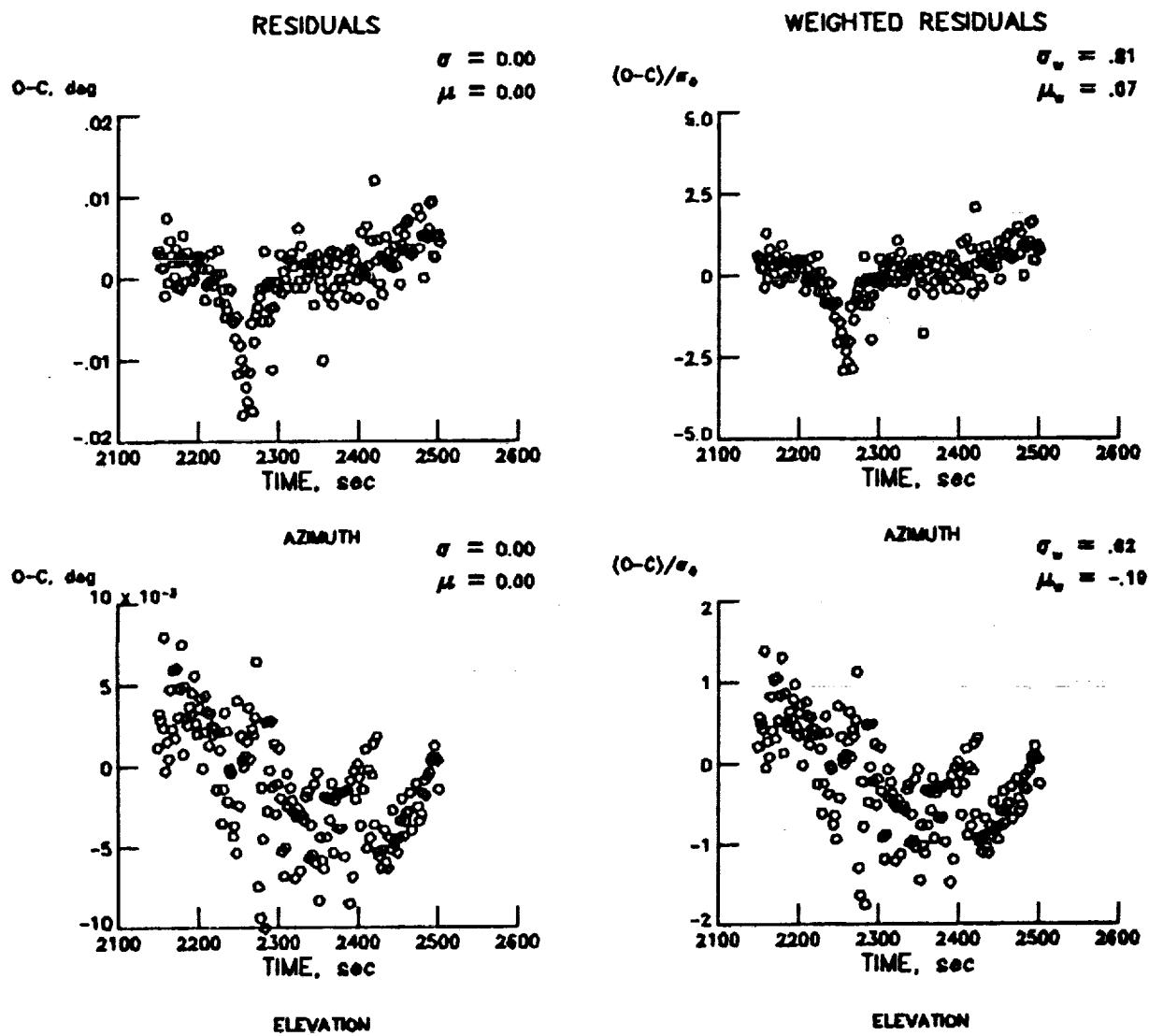


Figure A-13. Final cinetheodolite residuals from THEO5.

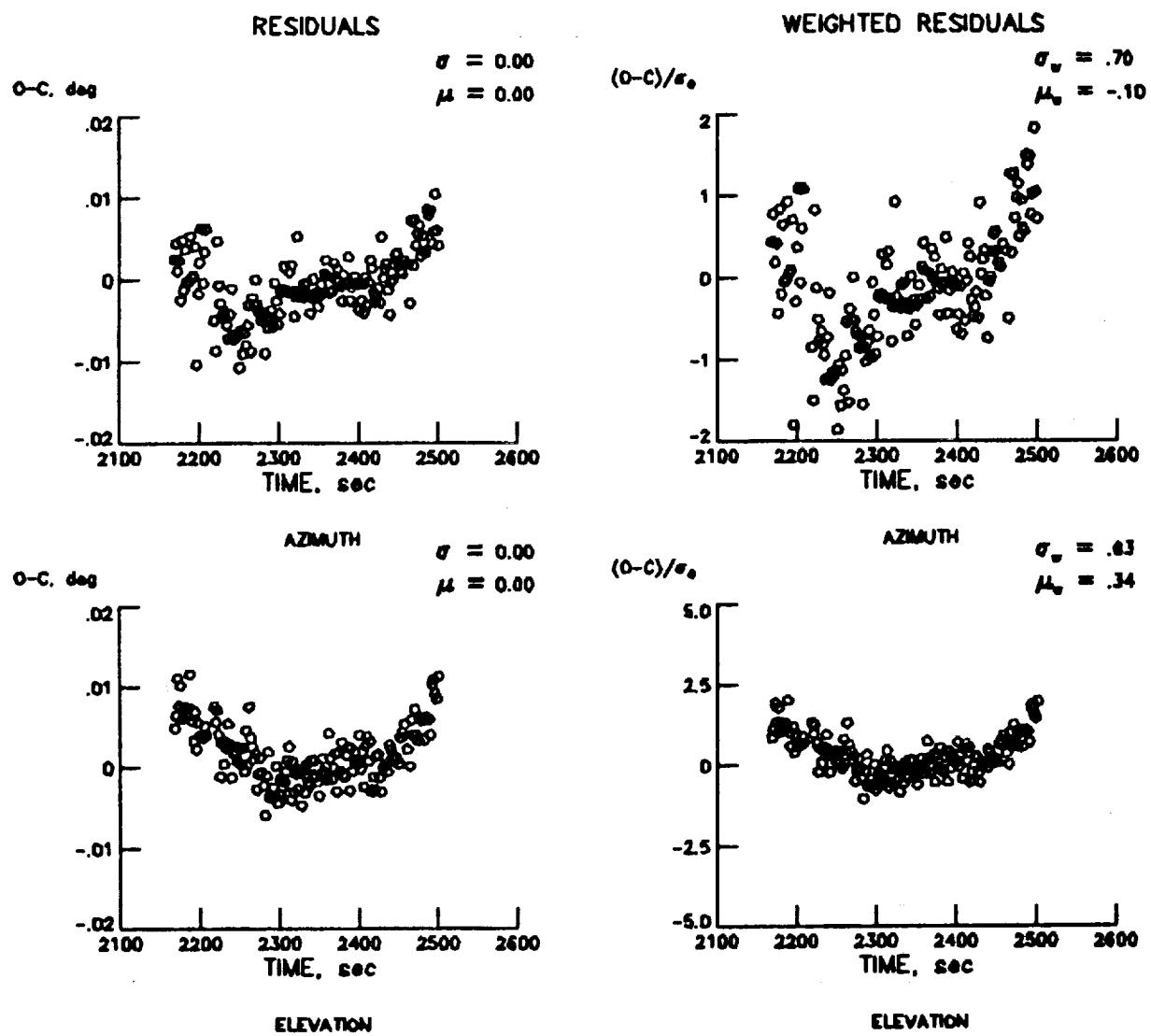


Figure A-14. Final cinetheodolite residuals from THEO6.

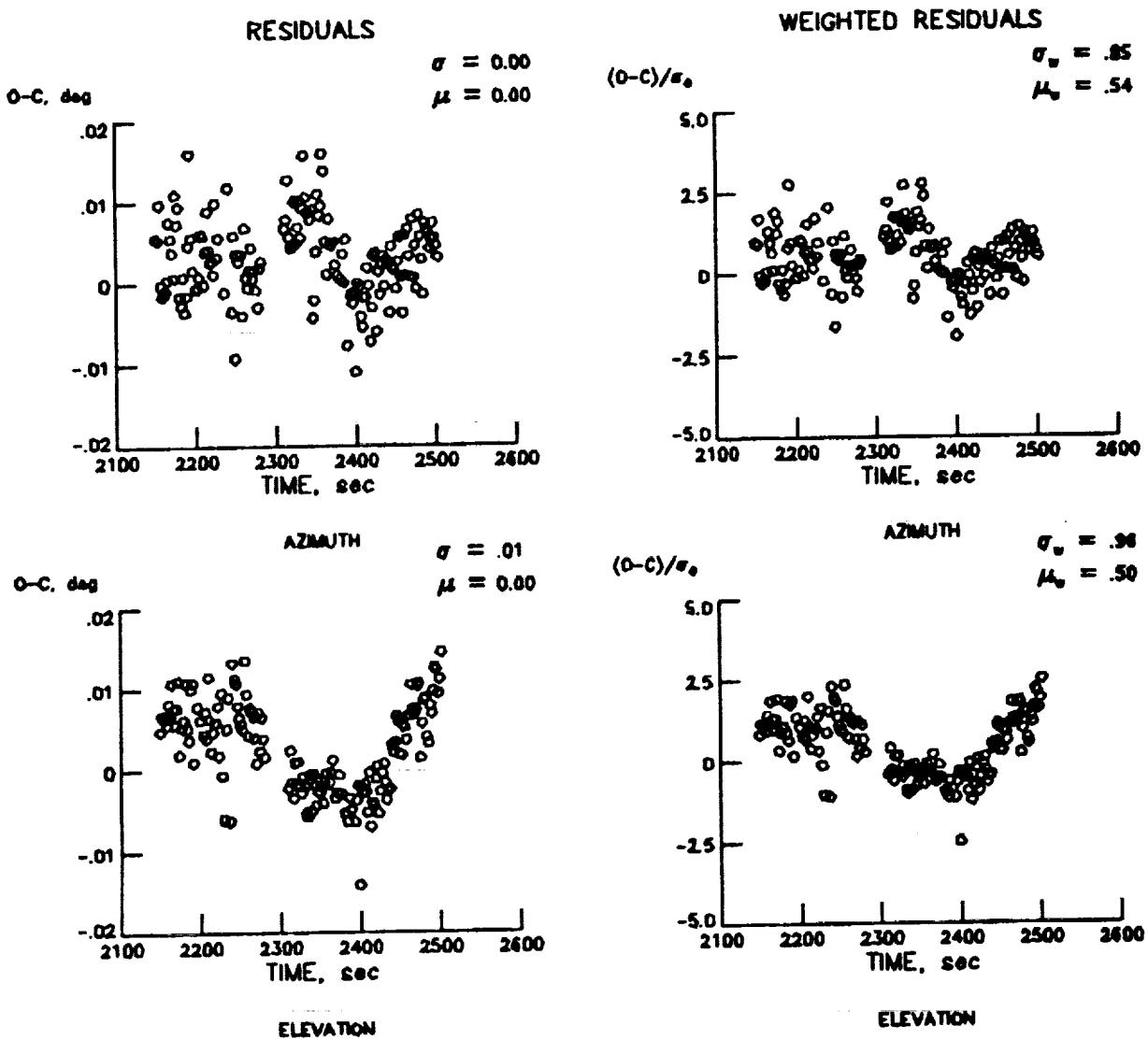


Figure A-15. Final cinetheodolite residuals from THEO7.

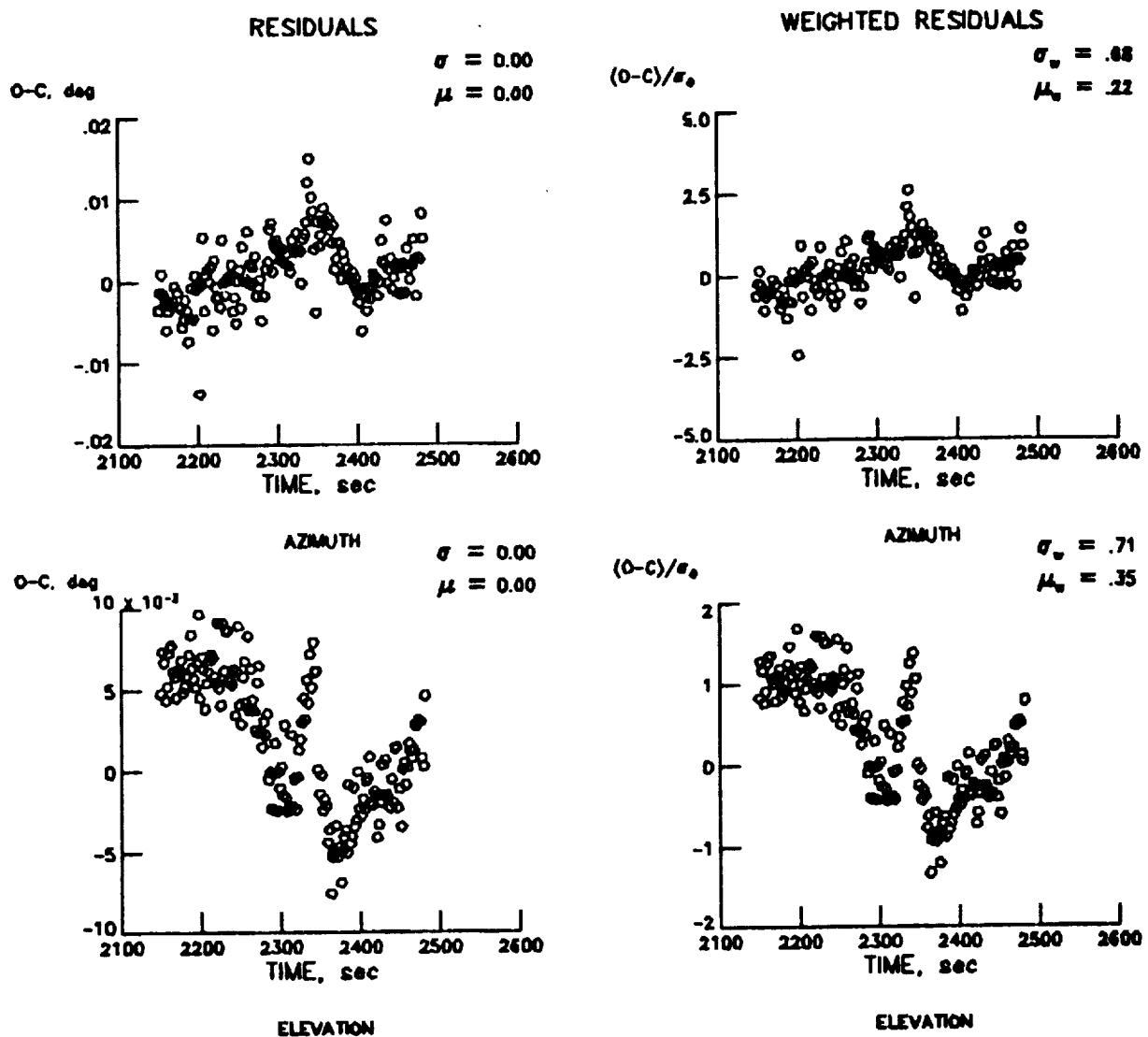


Figure A-16. Final cinetheodolite residuals from THEO8.

APPENDIX B

LISTING OF STS-40 TRAJECTORY AND AIR-DATA PARAMETERS FROM LaRC DESCENT BET

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
0	708426	24195.5	-1.185	49.45	-3.55	0.80	25.40	18.49			
2	707395	24196.8	-1.187	49.44	-3.51	0.73	25.56	18.49			
4	706363	24198.1	-1.188	49.42	-3.45	0.66	25.73	18.49			
6	705330	24199.4	-1.190	49.41	-3.42	0.60	25.86	18.49			
8	704296	24200.7	-1.191	49.39	-3.38	0.53	26.00	18.49			
10	703261	24202.0	-1.192	49.37	-3.34	0.46	26.13	18.49			
12	702225	24203.3	-1.194	49.36	-3.30	0.40	26.28	18.49			
14	701188	24204.5	-1.195	49.34	-3.28	0.33	26.43	18.49			
16	700151	24205.8	-1.196	49.33	-3.24	0.26	26.59	18.49			
18	699112	24207.1	-1.198	49.31	-3.22	0.20	26.75	18.50			
20	698073	24208.4	-1.199	49.30	-3.19	0.14	26.90	18.50			
22	697032	24209.7	-1.200	49.28	-3.18	0.07	27.04	18.50			
24	695991	24211.0	-1.202	49.27	-3.16	0.01	27.17	18.50			
26	694949	24212.3	-1.203	49.25	-3.14	-0.05	27.31	18.50			
28	693906	24213.6	-1.204	49.24	-3.12	-0.11	27.47	18.50			
30	692862	24214.9	-1.206	49.22	-3.11	-0.18	27.64	18.50			
32	691817	24216.2	-1.207	49.21	-3.10	-0.24	27.81	18.50			
34	690771	24217.5	-1.208	49.20	-3.09	-0.29	27.95	18.50			
36	689725	24218.8	-1.210	49.18	-3.09	-0.35	28.08	18.50			
38	688678	24220.1	-1.211	49.17	-3.09	-0.41	28.22	18.50			
40	687629	24221.4	-1.212	49.16	-3.09	-0.47	28.37	18.51			
42	686580	24222.7	-1.213	49.14	-3.08	-0.53	28.53	18.51			
44	685530	24224.0	-1.215	49.13	-3.08	-0.58	28.70	18.51			
46	684480	24225.3	-1.216	49.12	-3.09	-0.63	28.83	18.51			
48	683428	24226.6	-1.217	49.10	-3.09	-0.68	28.73	18.51			
50	682376	24227.9	-1.218	49.09	-3.10	-0.72	28.65	18.51			
52	681323	24229.2	-1.219	49.08	-3.10	-0.76	28.57	18.51			
54	680269	24230.5	-1.221	49.07	-3.10	-0.81	28.50	18.51			
56	679215	24231.9	-1.222	49.06	-3.12	-0.85	28.44	18.51			
58	678159	24233.2	-1.223	49.04	-3.13	-0.90	28.38	18.51			
60	677103	24234.5	-1.224	49.03	-3.15	-0.94	28.33	18.52			
62	676046	24235.8	-1.225	49.02	-3.17	-0.99	28.28	18.52			
64	674988	24237.1	-1.227	49.01	-3.19	-1.03	28.26	18.52			
66	673930	24238.4	-1.228	49.00	-3.21	-1.07	28.23	18.52			
68	672870	24239.8	-1.229	48.99	-3.24	-1.11	28.22	18.52			
70	671810	24241.1	-1.230	48.98	-3.26	-1.15	28.21	18.52			
72	670749	24242.4	-1.231	48.97	-3.30	-1.19	28.22	18.52			
74	669688	24243.7	-1.233	48.96	-3.33	-1.23	28.23	18.52			
76	668626	24245.0	-1.234	48.95	-3.35	-1.27	28.26	18.52			
78	667563	24246.4	-1.235	48.94	-3.39	-1.31	28.29	18.52			
80	666499	24247.7	-1.236	48.93	-3.43	-1.34	28.33	18.53			
82	665434	24249.0	-1.237	48.92	-3.47	-1.38	28.37	18.53			
84	664369	24250.3	-1.238	48.91	-3.51	-1.41	28.44	18.53			
86	663303	24251.7	-1.239	48.90	-3.49	-1.40	28.51	18.53			
88	662236	24253.0	-1.240	48.89	-3.32	-1.29	28.61	18.53			
90	661169	24254.3	-1.242	48.88	-3.15	-1.19	28.71	18.53			
92	660101	24255.7	-1.243	48.87	-2.98	-1.08	28.83	18.53			
94	659032	24257.0	-1.244	48.86	-2.82	-0.98	28.95	18.53			
96	657963	24258.3	-1.245	48.85	-2.65	-0.87	29.08	18.53			
98	656893	24259.6	-1.246	48.84	-2.50	-0.77	29.22	18.54			
100	655822	24261.0	-1.247	48.84	-2.35	-0.66	29.36	18.54			
102	654751	24262.3	-1.248	48.83	-2.21	-0.55	29.51	18.54			
104	653679	24263.6	-1.249	48.82	-2.06	-0.45	29.67	18.54			
106	652606	24265.0	-1.250	48.81	-1.91	-0.33	29.84	18.54			
108	651533	24266.3	-1.251	48.81	-1.78	-0.23	30.01	18.54			
110	650459	24267.7	-1.252	48.80	-1.64	-0.12	30.20	18.54			

Table B-1. STS-40 trajectory and air-data parameters.

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (paF)	VBAR	RNUM
112	649385	24269.0	-1.253	48.79	-1.52	-0.01	30.38	18.54			
114	648309	24270.3	-1.254	48.78	-1.40	0.10	30.58	18.54			
116	647234	24271.7	-1.255	48.78	-1.27	0.22	30.78	18.54			
118	646157	24273.0	-1.256	48.77	-1.15	0.33	30.99	18.55			
120	645080	24274.3	-1.257	48.76	-1.03	0.44	31.22	18.55			
122	644002	24275.7	-1.258	48.76	-0.93	0.56	31.43	18.55			
124	642924	24277.0	-1.259	48.75	-0.82	0.68	31.67	18.55			
126	641845	24278.4	-1.260	48.75	-0.73	0.79	31.91	18.55			
128	640766	24279.7	-1.261	48.74	-0.63	0.91	32.15	18.55			
130	639686	24281.1	-1.262	48.73	-0.53	1.03	32.41	18.55			
132	638606	24282.4	-1.263	48.73	-0.44	1.15	32.67	18.55			
134	637525	24283.8	-1.264	48.72	-0.35	1.27	32.94	18.55			
136	636443	24285.1	-1.265	48.72	-0.28	1.38	33.21	18.55			
138	635361	24286.4	-1.266	48.71	-0.19	1.51	33.49	18.56			
140	634278	24287.8	-1.267	48.71	-0.12	1.63	33.80	18.56			
142	633195	24289.1	-1.268	48.70	-0.04	1.76	34.10	18.56			
144	632111	24290.5	-1.269	48.70	0.03	1.88	34.40	18.56			
146	631027	24291.8	-1.270	48.70	0.08	2.00	34.71	18.56			
148	629942	24293.2	-1.271	48.69	0.13	2.12	35.03	18.56			
150	628857	24294.5	-1.271	48.69	0.19	2.25	35.36	18.56			
152	627771	24295.9	-1.272	48.68	0.24	2.38	35.62	18.56			
154	626685	24297.2	-1.273	48.68	0.29	2.51	35.84	18.56			
156	625598	24298.6	-1.274	48.68	0.34	2.64	36.01	18.56			
158	624511	24299.9	-1.275	48.67	0.39	2.78	36.19	18.57			
160	623423	24301.3	-1.276	48.67	0.42	2.91	36.32	18.57			
162	622335	24302.6	-1.277	48.67	0.46	3.04	36.48	18.57			
164	621246	24304.0	-1.277	48.67	0.48	3.17	36.63	18.57			
166	620157	24305.4	-1.278	48.66	0.52	3.30	36.79	18.57			
168	619068	24306.7	-1.279	48.66	0.54	3.43	36.97	18.57			
170	617978	24308.1	-1.280	48.66	0.57	3.57	37.09	18.57			
172	616887	24309.4	-1.281	48.66	0.59	3.71	37.23	18.57			
174	615796	24310.8	-1.281	48.65	0.60	3.84	37.37	18.57			
176	614705	24312.2	-1.282	48.65	0.61	3.98	37.52	18.58			
178	613614	24313.5	-1.283	48.65	0.62	4.11	37.67	18.58			
180	612521	24314.9	-1.284	48.65	0.62	4.24	37.84	18.58			
182	611429	24316.2	-1.285	48.65	0.63	4.38	38.01	18.58			
184	610336	24317.6	-1.285	48.65	0.63	4.51	38.15	18.58			
186	609243	24319.0	-1.286	48.65	0.61	4.65	38.28	18.58			
188	608149	24320.3	-1.287	48.65	0.60	4.76	38.42	18.58			
190	607055	24321.7	-1.288	48.65	0.58	4.81	38.57	18.58			
192	605960	24323.0	-1.288	48.65	0.52	4.82	38.73	18.58			
194	604866	24324.4	-1.289	48.64	0.47	4.84	38.89	18.58			
196	603770	24325.8	-1.290	48.64	0.43	4.86	39.07	18.59			
198	602675	24327.1	-1.290	48.65	0.38	4.85	39.17	18.59			
200	601579	24328.5	-1.291	48.65	0.31	4.82	39.14	18.59			
202	600483	24329.9	-1.292	48.65	0.25	4.79	39.11	18.59			
204	599386	24331.2	-1.293	48.65	0.18	4.76	39.09	18.59			
206	598289	24332.6	-1.293	48.65	0.12	4.72	39.09	18.59			
208	597192	24334.0	-1.294	48.65	0.04	4.69	39.08	18.59			
210	596095	24335.3	-1.295	48.65	-0.03	4.66	39.08	18.59			
212	594997	24336.7	-1.295	48.65	-0.11	4.63	39.10	18.59			
214	593899	24338.1	-1.296	48.65	-0.28	4.20	39.12	18.60			
216	592800	24339.4	-1.297	48.65	-0.11	3.28	39.19	18.60			
218	591702	24340.8	-1.297	48.66	0.35	2.59	39.28	18.60			
220	590603	24342.2	-1.298	48.66	0.80	1.89	39.39	18.60			

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
222	589503	24343.6	-1.299	48.66	1.33	1.56	39.49	18.60			
224	588403	24345.1	-1.300	48.66	2.05	2.04	40.03	18.60			
226	587303	24346.3	-1.300	48.67	2.74	2.44	40.80	18.60			
228	586203	24347.8	-1.300	48.67	2.67	2.07	41.19	18.60			
230	585103	24349.2	-1.301	48.67	1.99	1.15	41.70	18.60			
232	584002	24350.6	-1.302	48.67	1.35	0.26	42.19	18.60			
234	582901	24352.0	-1.302	48.68	1.10	-0.25	42.79	18.61			
236	581800	24353.3	-1.302	48.68	0.77	-0.82	43.33	18.61			
238	580699	24354.6	-1.302	48.68	0.83	-0.92	42.77	18.61			
240	579598	24356.0	-1.303	48.69	0.97	-0.49	42.03	18.61			
242	578497	24357.4	-1.304	48.69	0.69	0.45	41.35	18.61			
244	577395	24358.8	-1.304	48.70	0.12	1.16	40.72	18.61			
246	576294	24360.2	-1.305	48.70	-0.48	1.66	40.10	18.61			
248	575192	24361.5	-1.305	48.71	-1.28	1.25	39.47	18.61			
250	574089	24363.0	-1.306	48.71	-2.01	0.69	39.31	18.61			
252	572987	24364.4	-1.307	48.71	-2.01	-0.13	39.47	18.62			
254	571884	24365.8	-1.307	48.72	-1.82	-0.24	39.63	18.62			
256	570781	24367.2	-1.308	48.73	-1.62	-0.27	39.79	18.62			
258	569678	24368.6	-1.308	48.73	-1.40	-0.29	39.96	18.62			
260	568575	24369.9	-1.309	48.74	-1.21	-0.32	40.15	18.62			
262	567472	24371.3	-1.309	48.74	-1.02	-0.33	40.34	18.62			
264	566368	24372.7	-1.310	48.75	-0.83	-0.36	40.54	18.62			
266	565264	24374.1	-1.310	48.75	-0.63	-0.39	40.75	18.62			
268	564161	24375.4	-1.310	48.76	-0.44	-0.41	40.96	18.62			
270	563057	24376.8	-1.311	48.77	-0.24	-0.33	41.20	18.62			
272	561952	24378.2	-1.311	48.77	0.03	0.04	41.41	18.63			
274	560848	24379.6	-1.312	48.78	0.14	0.27	41.46	18.63			
276	559744	24380.9	-1.312	48.79	0.09	0.33	41.35	18.63			
278	558640	24382.3	-1.312	48.79	0.03	0.36	41.22	18.63			
280	557535	24383.7	-1.313	48.80	-0.09	0.07	41.09	18.63			
282	556431	24385.1	-1.313	48.81	-0.23	-0.22	40.97	18.63			
284	555326	24386.4	-1.314	48.82	-0.31	-0.29	40.85	18.63			
286	554222	24387.8	-1.314	48.82	-0.40	-0.35	40.74	18.63			
288	553117	24389.2	-1.314	48.83	-0.49	-0.40	40.64	18.63			
290	552012	24390.6	-1.315	48.84	-0.49	-0.37	40.55	18.64			
292	550907	24392.0	-1.315	48.85	-0.28	-0.14	40.50	18.64			
294	549802	24393.4	-1.316	48.86	-0.08	0.09	40.45	18.64			
296	548697	24394.7	-1.316	48.87	0.12	0.32	40.41	18.64			
298	547592	24396.1	-1.316	48.87	0.15	0.39	40.40	18.64			
300	546487	24397.5	-1.317	48.88	0.14	0.43	40.39	18.64			
302	545382	24398.9	-1.317	48.89	0.14	0.47	40.40	18.64			
304	544276	24400.2	-1.317	48.90	0.08	0.32	40.41	18.64			
306	543171	24401.6	-1.318	48.91	-0.01	-0.02	40.43	18.64			
308	542066	24403.0	-1.318	48.92	-0.07	-0.24	40.45	18.64			
310	540961	24404.4	-1.318	48.93	-0.12	-0.32	40.47	18.65			
312	539855	24405.8	-1.319	48.94	-0.15	-0.35	40.50	18.65			
314	538750	24407.2	-1.319	48.95	-0.12	-0.06	40.54	18.65			
316	537645	24408.5	-1.319	48.96	-0.09	0.23	40.58	18.65			
318	536540	24409.9	-1.319	48.97	-0.11	0.32	40.64	18.65			
320	535434	24411.3	-1.320	48.98	-0.13	0.36	40.69	18.65			
322	534329	24412.7	-1.320	48.99	-0.17	0.40	40.75	18.65			
324	533224	24414.1	-1.320	49.00	-0.20	0.45	40.82	18.65			
326	532119	24415.5	-1.320	49.02	-0.32	0.16	40.89	18.65			
328	531014	24416.8	-1.321	49.03	-0.44	-0.17	40.89	18.66			
330	529909	24418.2	-1.321	49.04	-0.33	-0.14	40.88	18.66			

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
332	528804	24419.6	-1.321	49.05	-0.04	0.21	40.91	18.66			
334	527699	24421.0	-1.321	49.06	0.01	0.36	40.80	18.66			
336	526594	24422.3	-1.321	49.08	0.01	0.31	40.67	18.66			
338	525489	24423.7	-1.322	49.09	0.01	0.20	40.56	18.66			
340	524385	24425.1	-1.322	49.10	0.00	0.09	40.46	18.66			
342	523280	24426.5	-1.322	49.11	-0.01	-0.02	40.36	18.66			
344	522176	24427.8	-1.322	49.13	-0.02	-0.14	40.27	18.66			
346	521071	24429.2	-1.322	49.14	-0.04	-0.24	40.19	18.66			
348	519967	24430.6	-1.322	49.15	-0.06	-0.31	40.12	18.67			
350	518863	24432.0	-1.323	49.17	-0.03	-0.18	40.04	18.67			
352	517759	24433.4	-1.323	49.18	-0.00	-0.05	39.98	18.67			
354	516655	24434.7	-1.323	49.19	0.03	0.09	39.92	18.67			
356	515551	24436.1	-1.323	49.21	0.05	0.21	39.88	18.67			
358	514447	24437.5	-1.323	49.22	0.07	0.35	39.84	18.67			
360	513344	24438.9	-1.323	49.24	0.04	0.29	39.80	18.67			
362	512240	24440.3	-1.323	49.25	-0.02	0.17	39.77	18.67			
364	511137	24441.6	-1.323	49.26	-0.05	0.06	39.75	18.67			
366	510034	24443.0	-1.323	49.28	-0.11	-0.07	39.74	18.68			
368	508931	24444.4	-1.324	49.29	-0.16	-0.19	39.74	18.68			
370	507828	24445.8	-1.324	49.31	-0.21	-0.31	39.74	18.68			
372	506725	24447.1	-1.324	49.32	-0.23	-0.23	39.74	18.68			
374	505623	24448.5	-1.324	49.34	-0.23	-0.11	39.75	18.68			
376	504521	24449.9	-1.324	49.36	-0.23	0.00	39.78	18.68			
378	503419	24451.3	-1.324	49.37	-0.24	0.14	39.81	18.68			
380	502317	24452.6	-1.324	49.39	-0.25	0.25	39.84	18.68			
382	501215	24454.0	-1.324	49.40	-0.27	0.38	39.89	18.68			
384	500113	24455.4	-1.324	49.42	-0.35	0.26	39.94	18.68			
386	499012	24456.8	-1.324	49.44	-0.44	0.13	39.99	18.69			
388	497911	24458.1	-1.324	49.45	-0.52	-0.01	40.05	18.69			
390	496810	24459.5	-1.324	49.47	-0.60	-0.13	40.13	18.69			
392	495710	24460.9	-1.324	49.49	-0.69	-0.26	40.21	18.69			
394	494609	24462.3	-1.324	49.51	-0.77	-0.37	40.30	18.69			
396	493509	24463.7	-1.324	49.52	-0.67	-0.33	40.41	18.69			
398	492409	24465.1	-1.324	49.54	-0.56	-0.27	40.54	18.69			
400	491310	24466.4	-1.324	49.56	-0.47	-0.21	40.66	18.69			
402	490210	24467.8	-1.324	49.58	-0.37	-0.15	40.81	18.69			
404	489111	24469.2	-1.324	49.60	-0.27	-0.11	40.95	18.70			
406	488013	24470.5	-1.324	49.61	-0.19	-0.05	41.07	18.70			
408	486914	24471.9	-1.324	49.63	-0.10	0.00	40.99	18.70			
410	485816	24473.3	-1.323	49.65	-0.02	0.05	40.91	18.70			
412	484718	24474.6	-1.323	49.67	0.06	0.10	40.83	18.70			
414	483621	24476.0	-1.323	49.69	0.13	0.14	40.77	18.70			
416	482523	24477.4	-1.323	49.71	0.21	0.19	40.71	18.70			
418	481426	24478.8	-1.323	49.73	0.29	0.24	40.66	18.70			
420	480330	24480.1	-1.323	49.75	0.35	0.28	40.62	18.70			
422	479233	24481.5	-1.323	49.77	0.42	0.33	40.60	18.70			
424	478137	24482.8	-1.323	49.79	0.47	0.37	40.57	18.71			
426	477042	24484.2	-1.322	49.81	0.53	0.41	40.55	18.71			
428	475946	24485.6	-1.322	49.83	0.58	0.45	40.54	18.71			
430	474851	24487.0	-1.322	49.85	0.63	0.49	40.54	18.71			
432	473757	24488.3	-1.322	49.87	0.68	0.53	40.54	18.71			
434	472663	24489.7	-1.322	49.89	0.45	0.31	40.57	18.71			
436	471569	24491.1	-1.322	49.91	0.18	0.06	40.62	18.71			
438	470475	24492.5	-1.322	49.93	-0.10	-0.20	40.68	18.71			
440	469382	24493.8	-1.321	49.96	-0.27	-0.37	40.76	18.71			

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
442	468289	24495.2	-1.321	49.98	-0.35	-0.44	40.78	18.72			
444	467197	24496.5	-1.321	50.00	-0.38	-0.28	40.76	18.72			
446	466105	24497.9	-1.321	50.02	-0.38	0.04	40.74	18.72			
448	465013	24499.3	-1.320	50.04	-0.40	0.25	40.73	18.72			
450	463922	24500.6	-1.320	50.07	-0.47	0.30	40.72	18.72			
452	462831	24502.0	-1.320	50.09	-0.57	0.24	40.72	18.72			
454	461741	24503.4	-1.320	50.11	-0.68	0.06	40.73	18.72			
456	460651	24504.7	-1.319	50.14	-0.80	-0.13	40.75	18.72			
458	459561	24506.1	-1.319	50.16	-0.92	-0.32	40.78	18.72			
460	458472	24507.5	-1.319	50.18	-0.80	-0.28	40.83	18.72			
462	457384	24508.8	-1.319	50.21	-0.62	-0.17	40.87	18.73			
464	456295	24510.2	-1.318	50.23	-0.46	-0.08	40.77	18.73			
466	455208	24511.5	-1.318	50.25	-0.28	0.02	40.67	18.73			
468	454121	24512.9	-1.318	50.28	-0.12	0.12	40.58	18.73			
470	453034	24514.2	-1.317	50.30	0.05	0.22	40.50	18.73			
472	451947	24515.6	-1.317	50.33	0.20	0.31	40.42	18.73			
474	450862	24516.9	-1.317	50.35	0.36	0.39	40.35	18.73			
476	449776	24518.3	-1.316	50.38	0.42	0.40	40.30	18.73			
478	448691	24519.7	-1.316	50.40	0.37	0.31	40.27	18.73			
480	447607	24521.0	-1.316	50.43	0.32	0.21	40.25	18.73			
482	446523	24522.4	-1.315	50.45	0.26	0.11	40.23	18.74			
484	445440	24523.8	-1.315	50.48	0.20	0.00	40.23	18.74			
486	444357	24525.1	-1.315	50.50	0.13	-0.10	40.22	18.74			
488	443274	24526.5	-1.314	50.53	0.07	-0.20	40.23	18.74			
490	442193	24527.8	-1.314	50.56	-0.01	-0.31	40.24	18.74			
492	441111	24529.2	-1.314	50.58	-0.05	-0.29	40.26	18.74			
494	440030	24530.5	-1.313	50.61	-0.07	-0.14	40.29	18.74			
496	438950	24531.9	-1.313	50.64	-0.10	-0.01	40.32	18.74			
498	437870	24533.2	-1.312	50.66	-0.12	0.14	40.36	18.74			
500	436791	24534.6	-1.312	50.69	-0.16	0.28	40.41	18.75			
502	435713	24535.9	-1.311	50.72	-0.21	0.37	40.46	18.75			
504	434634	24537.2	-1.311	50.75	-0.34	0.13	40.51	18.75			
506	433557	24538.6	-1.311	50.77	-0.47	-0.12	40.57	18.75			
508	432480	24540.0	-1.310	50.80	-0.59	-0.35	40.64	18.75			
510	431404	24541.3	-1.310	50.83	-0.38	-0.28	40.76	18.75			
512	430328	24542.7	-1.309	50.86	-0.11	-0.14	40.89	18.75			
514	429253	24544.0	-1.309	50.89	0.16	0.00	40.94	18.75			
516	428178	24545.3	-1.308	50.92	0.43	0.14	40.89	18.75			
518	427104	24546.7	-1.308	50.95	0.68	0.28	40.86	18.75			
520	426031	24548.0	-1.307	50.97	0.92	0.40	40.83	18.75			
522	424958	24549.4	-1.307	51.00	0.99	0.36	40.84	18.75			
524	423886	24550.7	-1.306	51.03	1.05	0.31	40.85	18.75			
526	422815	24552.0	-1.306	51.06	1.09	0.26	40.84	18.75			
528	421744	24553.4	-1.305	51.09	1.14	0.20	40.81	18.75			
530	420673	24554.7	-1.304	51.12	1.19	0.15	40.74	18.76			
532	419604	24556.0	-1.304	51.15	1.24	0.13	40.67	18.76			
534	418535	24557.4	-1.303	51.18	1.32	0.32	40.59	18.76			
536	417467	24558.7	-1.303	51.22	1.30	0.41	40.54	18.76			
538	416399	24560.0	-1.302	51.25	1.18	0.41	40.51	18.76			
540	415332	24561.4	-1.302	51.28	1.06	0.41	40.48	18.76			
542	414266	24562.7	-1.301	51.31	0.93	0.41	40.46	18.76			
544	413200	24564.1	-1.300	51.34	0.80	0.40	40.44	18.76			
546	412135	24565.4	-1.300	51.37	0.67	0.40	40.44	18.76			
548	411071	24566.7	-1.299	51.40	0.53	0.38	40.44	18.76			
550	410007	24568.1	-1.299	51.44	0.38	0.38	40.45	18.76			

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
552	408944	24569.4	-1.298	51.47	0.23	0.36	40.46	18.76			
554	407882	24570.7	-1.297	51.50	0.08	0.34	40.48	18.76			
556	406821	24572.0	-1.297	51.53	-0.08	0.32	40.52	18.76			
558	405760	24573.3	-1.296	51.57	-0.24	0.31	40.55	18.76			
560	404700	24574.7	-1.295	51.60	-0.40	0.28	40.59	18.76			
562	403641	24576.0	-1.295	51.63	-0.58	0.26	40.63	18.76			
564	402582	24577.3	-1.294	51.67	-0.76	0.19	40.68	18.76			
566	401524	24578.6	-1.293	51.70	-0.99	-0.17	40.74	18.76			
568	400467	24579.9	-1.293	51.73	-0.97	-0.32	40.83	18.76	0.01	0.8591	2.18E+02
570	399411	24566.7	-1.293	51.74	-0.73	-0.26	40.90	18.81	0.01	0.8500	2.24E+02
572	398355	24567.1	-1.292	51.78	-0.49	-0.19	40.98	18.91	0.01	0.8339	2.34E+02
574	397300	24567.4	-1.291	51.81	-0.26	-0.13	40.87	19.02	0.01	0.8182	2.45E+02
576	396246	24567.9	-1.291	51.84	-0.03	-0.05	40.71	19.13	0.01	0.8028	2.57E+02
578	395193	24568.3	-1.290	51.88	0.19	0.00	40.56	19.24	0.01	0.7877	2.69E+02
580	394141	24568.6	-1.289	51.91	0.41	0.07	40.41	19.35	0.01	0.7728	2.82E+02
582	393089	24568.7	-1.289	51.94	0.62	0.12	40.27	19.46	0.02	0.7577	2.96E+02
584	392038	24568.7	-1.288	51.98	0.84	0.18	40.13	19.57	0.02	0.7428	3.11E+02
586	390988	24568.6	-1.287	52.01	1.04	0.23	40.00	19.68	0.02	0.7281	3.26E+02
588	389939	24568.6	-1.287	52.04	1.26	0.28	39.87	19.80	0.02	0.7137	3.43E+02
590	388890	24568.5	-1.286	52.08	1.45	0.33	39.76	19.92	0.02	0.6997	3.60E+02
592	387842	24568.6	-1.285	52.11	1.66	0.38	39.64	20.04	0.02	0.6857	3.78E+02
594	386795	24569.0	-1.284	52.14	1.86	0.43	39.54	20.15	0.02	0.6715	3.98E+02
596	385749	24569.4	-1.284	52.18	2.04	0.47	39.44	20.27	0.02	0.6576	4.19E+02
598	384704	24569.8	-1.283	52.22	2.07	0.46	39.36	20.38	0.02	0.6440	4.40E+02
600	383660	24570.2	-1.282	52.25	1.78	0.27	39.32	20.50	0.02	0.6307	4.63E+02
602	382616	24570.6	-1.281	52.29	1.50	0.09	39.30	20.62	0.02	0.6176	4.87E+02
604	381573	24570.9	-1.281	52.32	1.25	0.05	39.27	20.74	0.02	0.6046	5.13E+02
606	380531	24571.1	-1.280	52.36	1.01	0.11	39.25	20.86	0.03	0.5915	5.41E+02
608	379490	24571.3	-1.279	52.40	0.76	0.15	39.23	20.97	0.03	0.5787	5.70E+02
610	378450	24571.5	-1.278	52.43	0.51	0.21	39.22	21.10	0.03	0.5662	6.01E+02
612	377411	24571.6	-1.277	52.47	0.23	0.16	39.21	21.22	0.03	0.5539	6.34E+02
614	376372	24571.8	-1.277	52.51	-0.09	-0.05	39.21	21.35	0.03	0.5419	6.68E+02
616	375335	24572.4	-1.276	52.54	-0.42	-0.25	39.21	21.47	0.03	0.5299	7.05E+02
618	374298	24573.3	-1.275	52.58	-0.67	-0.38	39.22	21.59	0.03	0.5179	7.45E+02
620	373262	24574.1	-1.274	52.62	-0.79	-0.41	39.31	21.71	0.04	0.5062	7.87E+02
622	372227	24575.0	-1.273	52.66	-0.93	-0.43	39.42	21.83	0.04	0.4948	8.31E+02
624	371193	24575.8	-1.272	52.70	-1.08	-0.46	39.53	21.96	0.04	0.4837	8.77E+02
626	370160	24576.6	-1.271	52.74	-1.23	-0.50	39.65	22.08	0.04	0.4728	9.27E+02
628	369128	24577.9	-1.270	52.78	-1.39	-0.54	39.77	22.21	0.04	0.4616	9.82E+02
630	368096	24579.3	-1.269	52.82	-1.40	-0.45	39.90	22.34	0.04	0.4505	1.04E+03
632	367066	24580.6	-1.268	52.86	-1.36	-0.30	40.06	22.48	0.05	0.4397	1.10E+03
634	366037	24582.0	-1.268	52.90	-1.33	-0.14	40.21	22.61	0.05	0.4292	1.17E+03
636	365008	24583.3	-1.267	52.94	-1.35	-0.18	40.36	22.75	0.05	0.4190	1.24E+03
638	363981	24584.6	-1.266	52.98	-1.38	-0.29	40.52	22.89	0.05	0.4089	1.31E+03
640	362954	24585.4	-1.265	53.02	-1.42	-0.40	40.68	23.01	0.06	0.3989	1.39E+03
642	361928	24586.0	-1.264	53.06	-1.35	-0.41	40.84	23.13	0.06	0.3891	1.47E+03
644	360904	24586.6	-1.263	53.10	-1.19	-0.33	41.03	23.25	0.06	0.3796	1.56E+03
646	359880	24587.1	-1.262	53.14	-1.04	-0.26	41.15	23.38	0.07	0.3703	1.66E+03
648	358857	24587.6	-1.261	53.18	-0.90	-0.18	41.14	23.50	0.07	0.3613	1.76E+03
650	357836	24588.1	-1.260	53.22	-0.76	-0.12	41.08	23.63	0.07	0.3524	1.86E+03
652	356815	24588.8	-1.259	53.26	-0.63	-0.05	40.95	23.74	0.08	0.3435	1.97E+03
654	355795	24589.4	-1.258	53.31	-0.50	0.02	40.83	23.85	0.08	0.3349	2.09E+03
656	354777	24590.0	-1.257	53.35	-0.38	0.08	40.70	23.97	0.09	0.3265	2.22E+03
658	353759	24590.6	-1.255	53.39	-0.28	0.13	40.58	24.08	0.09	0.3183	2.36E+03
660	352743	24591.1	-1.254	53.43	-0.18	0.18	40.45	24.20	0.09	0.3103	2.50E+03

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
662	351727	24591.7	-1.253	53.48	-0.09	0.22	40.32	24.32	0.10	0.3024	2.65E+03
664	350713	24592.9	-1.252	53.52	0.00	0.25	40.18	24.44	0.10	0.2944	2.82E+03
666	349699	24594.1	-1.251	53.56	0.07	0.29	40.05	24.57	0.11	0.2866	3.00E+03
668	348687	24595.3	-1.250	53.61	0.15	0.31	39.91	24.69	0.12	0.2790	3.19E+03
670	347676	24596.5	-1.249	53.65	0.20	0.34	39.77	24.82	0.12	0.2717	3.40E+03
672	346665	24597.7	-1.248	53.70	0.25	0.34	39.62	24.95	0.13	0.2645	3.62E+03
674	345656	24598.4	-1.246	53.74	0.29	0.35	39.46	25.06	0.14	0.2575	3.85E+03
676	344648	24597.5	-1.245	53.78	0.32	0.35	39.30	25.16	0.14	0.2507	4.08E+03
678	343642	24596.6	-1.244	53.82	0.34	0.34	39.14	25.25	0.15	0.2442	4.33E+03
680	342636	24595.6	-1.243	53.86	0.35	0.33	39.11	25.34	0.16	0.2377	4.60E+03
682	341631	24594.5	-1.242	53.90	0.34	0.30	39.09	25.44	0.17	0.2315	4.88E+03
684	340628	24593.4	-1.241	53.94	0.32	0.28	39.04	25.53	0.18	0.2255	5.18E+03
686	339626	24592.2	-1.240	53.98	0.31	0.25	39.21	25.62	0.19	0.2195	5.49E+03
688	338625	24591.4	-1.239	54.02	0.27	0.22	39.40	25.70	0.20	0.2137	5.82E+03
690	337625	24590.5	-1.237	54.06	0.23	0.17	39.59	25.78	0.21	0.2080	6.18E+03
692	336626	24589.6	-1.236	54.11	0.20	0.13	39.76	25.86	0.22	0.2025	6.55E+03
694	335629	24588.6	-1.235	54.15	0.14	0.08	39.93	25.94	0.23	0.1972	6.95E+03
696	334633	24587.7	-1.233	54.20	0.08	0.03	40.08	26.02	0.25	0.1920	7.37E+03
698	333638	24587.0	-1.232	54.24	0.02	-0.03	40.22	26.10	0.26	0.1869	7.82E+03
700	332645	24587.4	-1.231	54.29	-0.06	-0.10	40.34	26.19	0.28	0.1817	8.32E+03
702	331652	24587.9	-1.229	54.33	-0.13	-0.16	40.46	26.27	0.29	0.1768	8.84E+03
704	330662	24588.3	-1.228	54.38	-0.20	-0.22	40.55	26.36	0.31	0.1720	9.39E+03
706	329672	24588.7	-1.226	54.43	-0.28	-0.28	40.64	26.44	0.32	0.1673	9.98E+03
708	328684	24589.1	-1.225	54.48	-0.37	-0.36	40.71	26.53	0.34	0.1627	1.06E+04
710	327697	24588.0	-1.224	54.52	-0.45	-0.43	40.77	26.60	0.36	0.1584	1.13E+04
712	326712	24582.3	-1.222	54.56	-0.54	-0.52	40.82	26.64	0.38	0.1542	1.19E+04
714	325728	24576.3	-1.221	54.60	-0.61	-0.59	40.84	26.67	0.40	0.1502	1.26E+04
716	324746	24570.3	-1.220	54.63	-0.60	-0.60	40.87	26.71	0.42	0.1462	1.33E+04
718	323765	24564.3	-1.219	54.67	-0.36	-0.38	40.91	26.75	0.45	0.1424	1.41E+04
720	322785	24558.2	-1.217	54.71	-0.12	-0.16	40.94	26.78	0.47	0.1387	1.49E+04
722	321807	24552.8	-1.216	54.75	0.11	0.05	40.94	26.82	0.50	0.1351	1.57E+04
724	320830	24550.9	-1.214	54.80	0.20	0.14	40.90	26.85	0.52	0.1315	1.66E+04
726	319855	24549.4	-1.213	54.86	0.18	0.14	40.82	26.88	0.55	0.1281	1.75E+04
728	318882	24548.0	-1.211	54.91	0.13	0.12	40.73	26.91	0.58	0.1247	1.85E+04
730	317910	24546.6	-1.209	54.96	0.07	0.09	40.63	26.94	0.61	0.1215	1.96E+04
732	316939	24545.2	-1.208	55.02	-0.02	0.05	40.50	26.97	0.65	0.1183	2.07E+04
734	315971	24543.8	-1.206	55.07	-0.13	-0.01	40.36	27.00	0.68	0.1152	2.18E+04
736	315004	24542.4	-1.204	55.12	-0.27	-0.09	40.20	27.03	0.72	0.1122	2.31E+04
738	314038	24541.1	-1.202	55.18	-0.44	-0.18	40.02	27.07	0.76	0.1093	2.44E+04
740	313075	24539.7	-1.201	55.23	-0.62	-0.29	39.83	27.10	0.80	0.1064	2.57E+04
742	312113	24538.4	-1.199	55.29	-0.83	-0.42	39.63	27.13	0.84	0.1037	2.72E+04
744	311153	24537.1	-1.197	55.34	-1.05	-0.55	39.41	27.16	0.89	0.1010	2.87E+04
746	310194	24535.7	-1.195	55.40	-1.10	-0.52	39.19	27.20	0.93	0.0984	3.03E+04
748	309238	24536.5	-1.193	55.46	-1.03	-0.36	39.07	27.23	0.99	0.0958	3.20E+04
750	308283	24538.7	-1.190	55.52	-0.94	-0.21	39.01	27.27	1.04	0.0933	3.38E+04
752	307331	24541.1	-1.188	55.58	-0.86	-0.07	39.00	27.31	1.10	0.0909	3.58E+04
754	306381	24543.4	-1.185	55.64	-0.81	0.06	39.09	27.34	1.16	0.0885	3.78E+04
756	305432	24545.8	-1.183	55.71	-0.79	-0.01	39.16	27.38	1.22	0.0863	3.99E+04
758	304486	24548.4	-1.180	55.77	-0.79	-0.12	39.22	27.42	1.28	0.0840	4.22E+04
760	303543	24551.1	-1.177	55.83	-0.78	-0.23	39.28	27.44	1.35	0.0819	4.45E+04
762	302601	24553.1	-1.174	55.89	-0.74	-0.34	39.33	27.45	1.42	0.0798	4.68E+04
764	301662	24555.0	-1.172	55.95	-0.68	-0.43	39.37	27.46	1.50	0.0778	4.93E+04
766	300726	24557.0	-1.169	56.01	-0.57	-0.36	39.42	27.47	1.58	0.0758	5.19E+04
768	299793	24558.9	-1.165	56.07	-0.38	-0.06	39.46	27.48	1.66	0.0739	5.46E+04
770	298862	24560.8	-1.162	56.13	-0.21	0.22	39.50	27.48	1.75	0.0721	5.75E+04

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
772	297933	24562.9	-1.159	56.19	-0.25	0.30	39.58	27.49	1.84	0.0703	6.05E+04
774	297008	24566.2	-1.155	56.25	-0.35	0.14	39.65	27.50	1.93	0.0685	6.37E+04
776	296086	24569.4	-1.152	56.31	-0.46	-0.01	39.74	27.51	2.03	0.0669	6.70E+04
778	295166	24572.6	-1.148	56.38	-0.57	-0.18	39.84	27.52	2.14	0.0652	7.05E+04
780	294250	24575.8	-1.144	56.44	-0.66	-0.34	39.94	27.54	2.25	0.0636	7.41E+04
782	293337	24579.0	-1.141	56.50	-0.57	-0.36	40.08	27.55	2.36	0.0620	7.80E+04
784	292428	24582.2	-1.137	56.57	-0.38	-0.30	40.24	27.56	2.48	0.0605	8.20E+04
786	291521	24585.6	-1.133	56.63	-0.15	-0.21	40.40	27.56	2.61	0.0590	8.61E+04
788	290619	24588.9	-1.128	56.69	0.12	-0.11	40.59	27.55	2.74	0.0577	9.02E+04
790	289719	24592.1	-1.124	56.75	0.39	-0.02	40.79	27.53	2.87	0.0563	9.45E+04
792	288824	24595.2	-1.120	56.81	0.65	0.07	40.96	27.51	3.01	0.0550	9.89E+04
794	287932	24598.2	-1.115	56.87	0.88	0.12	41.11	27.50	3.16	0.0537	1.04E+05
796	287044	24601.1	-1.110	56.93	1.06	0.12	41.18	27.48	3.31	0.0525	1.08E+05
798	286160	24603.9	-1.105	56.99	1.20	0.10	41.11	27.47	3.47	0.0513	1.13E+05
800	285281	24606.5	-1.100	57.05	1.31	0.13	40.93	27.45	3.63	0.0501	1.19E+05
802	284407	24608.8	-1.094	57.12	1.38	0.28	40.62	27.43	3.80	0.0490	1.24E+05
804	283537	24611.1	-1.088	57.18	1.32	0.35	40.19	27.41	3.98	0.0479	1.30E+05
806	282672	24613.3	-1.082	57.24	1.12	0.31	39.67	27.40	4.16	0.0468	1.35E+05
808	281813	24615.4	-1.076	57.31	0.77	0.17	39.23	27.38	4.35	0.0458	1.41E+05
810	280959	24617.3	-1.069	57.37	0.33	-0.04	38.96	27.36	4.55	0.0448	1.48E+05
812	280112	24619.2	-1.062	57.44	-0.10	-0.24	38.83	27.34	4.75	0.0438	1.54E+05
814	279270	24621.9	-1.055	57.50	-0.42	-0.35	38.86	27.34	4.97	0.0428	1.61E+05
816	278434	24624.7	-1.047	57.56	-0.56	-0.36	38.96	27.33	5.20	0.0419	1.68E+05
818	277605	24627.4	-1.040	57.62	-0.56	-0.27	39.17	27.33	5.44	0.0410	1.76E+05
820	276782	24629.9	-1.032	57.68	-0.51	-0.15	39.48	27.33	5.68	0.0401	1.84E+05
822	275966	24632.2	-1.024	57.74	-0.51	-0.06	39.90	27.33	5.93	0.0392	1.92E+05
824	275158	24634.2	-1.015	57.80	-0.60	-0.05	40.39	27.33	6.20	0.0384	2.00E+05
826	274357	24636.0	-1.006	57.87	-0.80	-0.11	40.89	27.33	6.47	0.0376	2.09E+05
828	273564	24637.8	-0.997	57.93	-1.06	-0.22	41.24	27.32	6.74	0.0368	2.18E+05
830	272779	24639.5	-0.987	57.99	-1.29	-0.30	41.40	27.30	7.02	0.0361	2.27E+05
832	272003	24641.0	-0.976	58.05	-1.44	-0.31	41.32	27.29	7.31	0.0354	2.36E+05
834	271236	24642.4	-0.966	58.11	-1.54	-0.38	40.98	27.27	7.61	0.0347	2.45E+05
836	270477	24643.8	-0.955	58.17	-1.48	-0.43	40.40	27.26	7.91	0.0340	2.55E+05
838	269729	24644.9	-0.944	58.23	-1.26	-0.36	39.75	27.24	8.23	0.0333	2.64E+05
840	268989	24645.8	-0.932	58.29	-1.00	-0.26	39.28	27.23	8.55	0.0327	2.74E+05
842	268260	24646.5	-0.920	58.36	-0.83	-0.22	38.98	27.21	8.88	0.0321	2.85E+05
844	267542	24646.3	-0.907	58.42	-0.74	-0.25	38.84	27.20	9.21	0.0315	2.95E+05
846	266835	24645.5	-0.894	58.48	-0.69	-0.28	38.85	27.19	9.56	0.0309	3.06E+05
848	266141	24644.2	-0.879	58.55	-0.62	-0.31	39.04	27.18	9.91	0.0304	3.17E+05
850	265459	24642.5	-0.864	58.61	-0.48	-0.27	39.46	27.18	10.27	0.0298	3.29E+05
852	264790	24640.3	-0.848	58.67	-0.32	-0.23	40.12	27.17	10.63	0.0293	3.40E+05
854	264135	24637.7	-0.832	58.74	-0.18	-0.20	40.73	27.16	11.00	0.0288	3.52E+05
856	263495	24634.5	-0.815	58.80	-0.08	-0.19	41.14	27.15	11.37	0.0283	3.64E+05
858	262869	24631.0	-0.797	58.86	0.02	-0.18	41.31	27.13	11.75	0.0279	3.75E+05
860	262259	24627.0	-0.779	58.93	0.11	-0.16	41.24	27.12	12.12	0.0274	3.87E+05
862	261665	24621.7	-0.761	58.99	0.22	-0.14	40.93	27.10	12.49	0.0270	3.99E+05
864	261087	24615.1	-0.742	59.06	0.34	-0.13	40.46	27.08	12.85	0.0266	4.10E+05
866	260525	24608.4	-0.724	59.13	0.48	-0.11	39.96	27.05	13.21	0.0263	4.21E+05
868	259979	24601.8	-0.705	59.20	0.64	-0.10	39.48	27.02	13.57	0.0259	4.32E+05
870	259450	24595.2	-0.686	59.26	0.80	-0.12	39.17	27.00	13.92	0.0256	4.43E+05
872	258938	24588.4	-0.666	59.33	1.02	-0.06	39.13	26.97	14.27	0.0252	4.54E+05
874	258442	24581.3	-0.646	59.40	1.14	0.08	39.37	26.95	14.62	0.0249	4.64E+05
876	257964	24573.7	-0.625	59.47	1.09	0.07	39.78	26.92	14.97	0.0246	4.75E+05
878	257505	24565.5	-0.603	59.54	0.99	0.03	40.25	26.90	15.30	0.0243	4.85E+05
880	257065	24556.9	-0.581	59.60	1.48	-0.79	40.62	26.87	15.63	0.0241	4.96E+05

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
882	256644	24548.0	-0.559	59.67	5.14	-1.24	40.88	26.85	15.95	0.0238	5.05E+05
884	256242	24538.8	-0.536	59.74	11.07	-0.38	40.97	26.82	16.26	0.0236	5.15E+05
886	255861	24529.3	-0.513	59.82	17.20	-0.06	40.84	26.80	16.56	0.0234	5.24E+05
888	255498	24519.8	-0.491	59.90	23.14	-0.05	40.42	26.78	16.86	0.0231	5.34E+05
890	255154	24510.3	-0.470	59.98	29.11	-0.15	39.92	26.77	17.13	0.0229	5.42E+05
892	254828	24500.9	-0.451	60.06	35.35	-0.18	39.47	26.75	17.40	0.0228	5.51E+05
894	254517	24491.8	-0.433	60.15	41.88	-0.13	39.16	26.73	17.66	0.0226	5.59E+05
896	254221	24482.6	-0.418	60.23	48.43	0.04	39.08	26.71	17.91	0.0224	5.67E+05
898	253936	24473.3	-0.405	60.32	54.09	0.84	39.22	26.70	18.16	0.0223	5.74E+05
900	253663	24463.8	-0.393	60.41	57.22	0.82	39.39	26.68	18.39	0.0221	5.82E+05
902	253398	24454.1	-0.382	60.51	59.10	0.32	39.56	26.66	18.62	0.0220	5.89E+05
904	253144	24444.3	-0.371	60.60	60.85	0.12	39.71	26.65	18.85	0.0218	5.96E+05
906	252898	24434.2	-0.361	60.70	62.68	0.24	39.85	26.63	19.06	0.0217	6.03E+05
908	252660	24423.9	-0.352	60.79	64.20	0.26	40.09	26.61	19.28	0.0215	6.10E+05
910	252430	24413.2	-0.343	60.89	65.45	0.33	40.34	26.60	19.48	0.0214	6.16E+05
912	252207	24402.1	-0.334	60.98	66.34	0.28	40.50	26.58	19.68	0.0213	6.23E+05
914	251992	24390.9	-0.326	61.08	67.18	0.26	40.49	26.56	19.88	0.0212	6.29E+05
916	251783	24379.7	-0.318	61.18	68.01	0.27	40.33	26.55	20.07	0.0211	6.35E+05
918	251581	24368.6	-0.311	61.28	68.77	0.29	40.10	26.53	20.25	0.0210	6.41E+05
920	251384	24357.5	-0.304	61.38	69.43	0.28	39.90	26.51	20.44	0.0209	6.47E+05
922	251193	24346.4	-0.298	61.48	70.04	0.28	39.76	26.50	20.61	0.0208	6.53E+05
924	251008	24335.2	-0.292	61.58	70.55	0.27	39.72	26.48	20.78	0.0207	6.58E+05
926	250827	24323.9	-0.286	61.68	71.00	0.24	39.78	26.46	20.95	0.0206	6.64E+05
928	250652	24312.4	-0.280	61.78	71.65	0.16	39.91	26.45	21.12	0.0205	6.69E+05
930	250481	24300.9	-0.275	61.88	72.47	0.26	40.04	26.43	21.28	0.0204	6.74E+05
932	250314	24289.1	-0.270	61.98	73.16	0.31	40.11	26.41	21.43	0.0203	6.80E+05
934	250151	24277.2	-0.266	62.09	73.71	0.31	40.09	26.40	21.59	0.0202	6.85E+05
936	249992	24265.4	-0.262	62.19	74.14	0.30	40.02	26.38	21.74	0.0201	6.90E+05
938	249835	24253.4	-0.258	62.29	74.52	0.32	39.93	26.36	21.88	0.0201	6.94E+05
940	249682	24241.5	-0.255	62.40	74.76	0.31	39.86	26.34	22.02	0.0200	6.99E+05
942	249531	24229.6	-0.252	62.50	74.91	0.30	39.84	26.32	22.16	0.0199	7.03E+05
944	249383	24217.6	-0.249	62.60	75.05	0.18	39.88	26.31	22.30	0.0198	7.08E+05
946	249236	24205.4	-0.246	62.71	75.28	0.19	39.95	26.29	22.43	0.0198	7.12E+05
948	249093	24193.2	-0.244	62.81	75.46	0.23	40.01	26.27	22.56	0.0197	7.16E+05
950	248951	24180.9	-0.241	62.92	75.65	0.17	40.05	26.25	22.69	0.0196	7.21E+05
952	248811	24168.5	-0.239	63.02	75.88	0.18	40.07	26.23	22.82	0.0196	7.25E+05
954	248672	24156.1	-0.237	63.13	76.09	0.22	40.05	26.21	22.96	0.0195	7.29E+05
956	248536	24143.6	-0.235	63.23	76.17	0.24	39.99	26.19	23.08	0.0194	7.33E+05
958	248400	24131.1	-0.234	63.34	76.00	0.15	39.94	26.17	23.20	0.0194	7.37E+05
960	248266	24118.6	-0.232	63.44	75.94	0.02	39.89	26.15	23.33	0.0193	7.41E+05
962	248133	24105.8	-0.230	63.55	76.18	0.12	39.87	26.14	23.45	0.0192	7.45E+05
964	248002	24092.9	-0.229	63.66	76.33	0.19	39.86	26.12	23.58	0.0192	7.50E+05
966	247871	24079.9	-0.228	63.77	76.23	0.13	39.91	26.10	23.70	0.0191	7.54E+05
968	247741	24066.8	-0.226	63.87	76.08	0.08	39.96	26.08	23.82	0.0190	7.58E+05
970	247613	24053.8	-0.225	63.98	75.94	0.08	40.00	26.06	23.94	0.0190	7.62E+05
972	247485	24040.6	-0.224	64.09	75.78	0.11	40.03	26.04	24.06	0.0189	7.66E+05
974	247358	24027.3	-0.223	64.20	75.51	0.09	40.06	26.02	24.18	0.0189	7.70E+05
976	247233	24013.9	-0.221	64.31	75.17	0.04	40.05	26.00	24.30	0.0188	7.74E+05
978	247108	24000.5	-0.220	64.42	74.82	0.04	40.00	25.98	24.42	0.0188	7.77E+05
980	246984	23987.2	-0.218	64.53	74.57	-0.07	39.95	25.96	24.53	0.0187	7.81E+05
982	246862	23973.7	-0.217	64.64	74.67	-0.03	39.91	25.94	24.65	0.0186	7.85E+05
984	246741	23960.2	-0.216	64.75	74.83	0.05	39.86	25.92	24.77	0.0186	7.89E+05
986	246620	23946.8	-0.215	64.86	74.87	0.04	39.83	25.90	24.88	0.0185	7.93E+05
988	246500	23933.3	-0.214	64.98	74.87	0.01	39.82	25.88	24.99	0.0185	7.97E+05
990	246381	23919.8	-0.213	65.09	74.91	0.00	39.87	25.86	25.11	0.0184	8.01E+05

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
992	246262	23906.2	-0.212	65.20	74.92	-0.02	39.92	25.85	25.22	0.0184	8.05E+05
994	246143	23892.6	-0.212	65.31	74.96	-0.04	39.97	25.83	25.34	0.0183	8.08E+05
996	246025	23878.9	-0.212	65.43	75.03	-0.06	40.01	25.81	25.45	0.0183	8.12E+05
998	245906	23865.1	-0.212	65.54	75.19	-0.02	40.05	25.79	25.57	0.0182	8.16E+05
1000	245788	23851.0	-0.211	65.65	75.35	-0.01	40.09	25.77	25.68	0.0182	8.20E+05
1002	245670	23836.9	-0.212	65.77	75.43	-0.06	40.09	25.75	25.80	0.0181	8.24E+05
1004	245551	23822.8	-0.212	65.88	75.56	-0.08	40.07	25.73	25.91	0.0180	8.28E+05
1006	245431	23808.9	-0.213	66.00	75.78	-0.04	40.00	25.71	26.03	0.0180	8.32E+05
1008	245311	23794.9	-0.214	66.11	75.99	-0.00	39.94	25.69	26.15	0.0179	8.36E+05
1010	245189	23781.0	-0.215	66.23	76.18	0.02	39.89	25.67	26.27	0.0179	8.40E+05
1012	245067	23766.9	-0.217	66.34	76.35	0.03	39.86	25.65	26.39	0.0178	8.44E+05
1014	244942	23752.7	-0.218	66.46	76.44	0.10	39.88	25.63	26.52	0.0178	8.48E+05
1016	244817	23738.4	-0.220	66.57	76.09	0.07	39.94	25.61	26.65	0.0177	8.53E+05
1018	244689	23724.1	-0.221	66.69	75.64	-0.00	39.97	25.59	26.79	0.0177	8.57E+05
1020	244561	23709.6	-0.223	66.81	75.31	0.03	40.01	25.57	26.91	0.0176	8.62E+05
1022	244431	23695.0	-0.224	66.93	74.97	0.07	40.05	25.54	27.04	0.0176	8.66E+05
1024	244300	23680.3	-0.225	67.04	74.59	0.10	40.07	25.52	27.17	0.0175	8.70E+05
1026	244168	23665.6	-0.226	67.16	74.06	0.13	40.08	25.50	27.30	0.0174	8.75E+05
1028	244035	23650.8	-0.227	67.28	73.36	0.07	40.03	25.48	27.46	0.0174	8.80E+05
1030	243901	23635.6	-0.227	67.40	72.73	0.08	39.98	25.46	27.59	0.0173	8.85E+05
1032	243767	23620.2	-0.227	67.52	72.03	0.06	39.93	25.43	27.73	0.0173	8.89E+05
1034	243634	23604.3	-0.226	67.64	71.31	0.04	39.91	25.41	27.86	0.0172	8.93E+05
1036	243501	23588.3	-0.225	67.76	70.62	0.05	39.92	25.39	27.99	0.0172	8.98E+05
1038	243370	23572.3	-0.223	67.89	69.90	0.05	39.87	25.36	28.12	0.0171	9.02E+05
1040	243239	23556.1	-0.221	68.01	69.35	-0.03	39.82	25.34	28.25	0.0171	9.06E+05
1042	243111	23540.0	-0.219	68.13	69.06	0.02	39.76	25.31	28.37	0.0170	9.11E+05
1044	242984	23523.6	-0.217	68.26	68.71	0.04	39.67	25.29	28.50	0.0170	9.15E+05
1046	242859	23507.2	-0.214	68.38	68.31	0.05	39.57	25.26	28.62	0.0169	9.19E+05
1048	242736	23490.6	-0.212	68.51	67.87	0.04	39.43	25.24	28.75	0.0168	9.23E+05
1050	242615	23474.2	-0.209	68.63	67.36	0.02	39.26	25.21	28.86	0.0168	9.27E+05
1052	242496	23457.9	-0.205	68.75	66.84	0.00	39.10	25.19	28.97	0.0168	9.31E+05
1054	242380	23441.6	-0.202	68.88	66.31	0.00	38.95	25.17	29.09	0.0167	9.35E+05
1056	242267	23425.5	-0.199	69.00	65.78	0.00	38.83	25.14	29.20	0.0167	9.39E+05
1058	242156	23409.4	-0.195	69.13	65.23	0.00	38.78	25.12	29.30	0.0166	9.42E+05
1060	242048	23393.3	-0.191	69.25	64.71	-0.06	38.78	25.10	29.41	0.0166	9.46E+05
1062	241943	23377.1	-0.187	69.38	64.42	-0.08	38.83	25.07	29.52	0.0165	9.50E+05
1064	241842	23360.8	-0.183	69.50	64.28	-0.04	38.87	25.05	29.60	0.0165	9.53E+05
1066	241744	23344.4	-0.179	69.63	64.37	-0.10	38.90	25.03	29.69	0.0165	9.56E+05
1068	241649	23328.0	-0.175	69.75	64.67	-0.04	38.87	25.00	29.78	0.0164	9.59E+05
1070	241556	23311.7	-0.171	69.88	64.90	-0.04	38.83	24.98	29.87	0.0164	9.63E+05
1072	241466	23295.4	-0.168	70.00	65.15	-0.05	38.79	24.96	29.94	0.0163	9.65E+05
1074	241378	23279.0	-0.166	70.13	65.44	-0.07	38.76	24.94	30.02	0.0163	9.68E+05
1076	241292	23262.8	-0.164	70.26	65.82	-0.04	38.73	24.91	30.10	0.0163	9.71E+05
1078	241207	23246.6	-0.162	70.38	66.19	-0.05	38.74	24.89	30.18	0.0162	9.74E+05
1080	241123	23230.3	-0.161	70.51	66.56	-0.07	38.84	24.87	30.24	0.0162	9.76E+05
1082	241040	23213.8	-0.160	70.64	67.02	-0.05	38.98	24.85	30.31	0.0162	9.79E+05
1084	240958	23197.1	-0.159	70.77	67.27	0.01	39.08	24.83	30.38	0.0161	9.82E+05
1086	240876	23180.4	-0.159	70.90	67.31	-0.06	39.10	24.80	30.45	0.0161	9.84E+05
1088	240793	23163.8	-0.158	71.03	67.38	-0.09	39.07	24.78	30.52	0.0161	9.87E+05
1090	240711	23147.2	-0.159	71.15	67.56	-0.06	39.05	24.76	30.59	0.0160	9.90E+05
1092	240628	23130.6	-0.159	71.28	67.73	-0.04	39.12	24.74	30.66	0.0160	9.93E+05
1094	240544	23114.0	-0.160	71.41	67.88	-0.03	39.24	24.72	30.74	0.0160	9.95E+05
1096	240459	23097.3	-0.161	71.54	67.96	-0.06	39.37	24.69	30.81	0.0160	9.98E+05
1098	240373	23080.6	-0.162	71.67	68.11	-0.05	39.49	24.67	30.89	0.0159	1.00E+06
1100	240286	23063.7	-0.164	71.80	68.29	-0.02	39.61	24.65	30.96	0.0159	1.00E+06

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
1102	240197	23046.7	-0.166	71.93	68.43	-0.00	39.74	24.62	31.04	0.0159	1.01E+06
1104	240106	23029.4	-0.168	72.06	68.47	-0.07	39.85	24.60	31.14	0.0158	1.01E+06
1106	240014	23011.9	-0.170	72.19	68.54	-0.08	39.90	24.58	31.21	0.0158	1.01E+06
1108	239919	22994.3	-0.172	72.33	68.69	-0.06	39.89	24.55	31.28	0.0157	1.02E+06
1110	239823	22976.6	-0.174	72.46	68.84	-0.02	39.87	24.53	31.38	0.0157	1.02E+06
1112	239725	22959.0	-0.177	72.59	68.90	-0.03	39.85	24.51	31.47	0.0157	1.02E+06
1114	239624	22941.0	-0.179	72.73	68.99	-0.02	39.85	24.48	31.57	0.0156	1.03E+06
1116	239521	22923.1	-0.182	72.86	68.85	0.07	39.88	24.46	31.66	0.0156	1.03E+06
1118	239415	22905.4	-0.185	72.99	68.34	0.01	39.87	24.43	31.77	0.0156	1.03E+06
1120	239306	22887.9	-0.188	73.13	67.82	-0.02	39.82	24.41	31.88	0.0155	1.04E+06
1122	239195	22869.8	-0.191	73.26	67.30	-0.03	39.80	24.38	31.99	0.0155	1.04E+06
1124	239082	22851.7	-0.192	73.39	66.75	-0.04	39.81	24.36	32.11	0.0154	1.05E+06
1126	238968	22833.4	-0.194	73.53	66.19	-0.04	39.87	24.33	32.21	0.0154	1.05E+06
1128	238853	22815.1	-0.195	73.66	65.59	-0.08	39.90	24.31	32.33	0.0153	1.05E+06
1130	238736	22796.8	-0.196	73.80	65.00	-0.10	39.91	24.28	32.45	0.0153	1.06E+06
1132	238618	22778.4	-0.197	73.93	64.43	-0.10	39.88	24.25	32.57	0.0153	1.06E+06
1134	238500	22760.0	-0.197	74.07	63.88	-0.10	39.84	24.23	32.69	0.0152	1.07E+06
1136	238382	22741.6	-0.197	74.20	63.36	-0.10	39.82	24.20	32.82	0.0152	1.07E+06
1138	238263	22723.3	-0.197	74.34	62.90	-0.20	39.81	24.18	32.94	0.0151	1.08E+06
1140	238144	22705.1	-0.198	74.47	62.88	-0.19	39.85	24.15	33.07	0.0151	1.08E+06
1142	238024	22686.8	-0.198	74.61	63.01	-0.12	39.89	24.13	33.19	0.0150	1.08E+06
1144	237904	22668.0	-0.198	74.74	63.07	-0.15	39.95	24.10	33.32	0.0150	1.09E+06
1146	237784	22649.2	-0.198	74.88	63.13	-0.20	39.98	24.07	33.44	0.0150	1.09E+06
1148	237663	22630.3	-0.199	75.02	63.41	-0.14	39.99	24.05	33.56	0.0149	1.10E+06
1150	237542	22611.5	-0.200	75.15	63.67	-0.13	39.97	24.02	33.69	0.0149	1.10E+06
1152	237419	22592.7	-0.202	75.29	63.91	-0.14	39.95	23.99	33.82	0.0148	1.11E+06
1154	237294	22573.9	-0.203	75.43	64.18	-0.15	39.96	23.96	33.95	0.0148	1.11E+06
1156	237168	22555.1	-0.206	75.56	64.53	-0.12	39.99	23.94	34.07	0.0147	1.12E+06
1158	237040	22536.2	-0.209	75.70	64.91	-0.06	40.01	23.91	34.19	0.0147	1.12E+06
1160	236909	22517.1	-0.212	75.84	65.13	-0.01	40.01	23.88	34.34	0.0147	1.13E+06
1162	236775	22497.9	-0.215	75.98	65.12	-0.05	39.98	23.86	34.49	0.0146	1.13E+06
1164	236638	22478.7	-0.218	76.12	64.99	-0.02	39.95	23.83	34.64	0.0146	1.14E+06
1166	236499	22459.4	-0.222	76.26	64.63	-0.02	39.93	23.80	34.79	0.0145	1.14E+06
1168	236356	22440.0	-0.225	76.40	64.11	-0.03	39.98	23.77	34.95	0.0145	1.15E+06
1170	236212	22420.6	-0.228	76.54	63.58	-0.04	40.02	23.74	35.11	0.0144	1.15E+06
1172	236065	22401.0	-0.230	76.68	63.05	-0.04	40.04	23.72	35.26	0.0144	1.16E+06
1174	235916	22381.2	-0.232	76.82	62.49	-0.07	40.02	23.69	35.44	0.0143	1.16E+06
1176	235766	22361.4	-0.233	76.96	61.94	-0.07	39.99	23.66	35.61	0.0143	1.17E+06
1178	235615	22341.6	-0.235	77.10	61.39	-0.08	39.99	23.63	35.79	0.0142	1.18E+06
1180	235462	22321.5	-0.235	77.25	60.86	-0.09	39.99	23.60	35.96	0.0142	1.18E+06
1182	235309	22301.1	-0.235	77.39	60.35	-0.10	40.03	23.57	36.14	0.0141	1.19E+06
1184	235156	22280.7	-0.235	77.53	59.83	-0.11	40.00	23.54	36.32	0.0141	1.20E+06
1186	235003	22260.3	-0.235	77.67	59.31	-0.13	39.84	23.51	36.49	0.0140	1.20E+06
1188	234851	22240.0	-0.234	77.81	58.85	-0.12	39.70	23.48	36.67	0.0140	1.21E+06
1190	234698	22219.9	-0.233	77.95	58.47	-0.10	39.66	23.45	36.85	0.0139	1.21E+06
1192	234546	22199.9	-0.233	78.09	58.14	-0.15	39.72	23.42	37.03	0.0139	1.22E+06
1194	234395	22179.6	-0.232	78.23	58.25	-0.16	39.77	23.39	37.21	0.0138	1.23E+06
1196	234243	22159.0	-0.231	78.38	58.45	-0.13	39.80	23.36	37.39	0.0138	1.23E+06
1198	234092	22138.5	-0.231	78.52	58.67	-0.12	39.76	23.33	37.57	0.0137	1.24E+06
1200	233941	22117.6	-0.231	78.66	58.93	-0.13	39.74	23.30	37.75	0.0137	1.25E+06
1202	233790	22096.7	-0.231	78.81	59.25	-0.09	39.70	23.27	37.93	0.0136	1.25E+06
1204	233639	22075.9	-0.231	78.95	59.40	-0.05	39.65	23.24	38.11	0.0136	1.26E+06
1206	233486	22055.2	-0.232	79.09	59.49	-0.09	39.61	23.21	38.30	0.0135	1.27E+06
1208	233333	22034.4	-0.234	79.24	59.74	-0.03	39.59	23.18	38.48	0.0135	1.27E+06
1210	233178	22013.7	-0.236	79.38	59.98	-0.01	39.58	23.15	38.67	0.0134	1.28E+06

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
1212	233021	21993.0	-0.238	79.53	60.23	-0.03	39.72	23.12	38.87	0.0134	1.29E+06
1214	232862	21972.0	-0.240	79.67	60.50	-0.02	39.86	23.09	39.08	0.0133	1.29E+06
1216	232701	21950.7	-0.243	79.82	60.56	0.01	39.98	23.06	39.27	0.0133	1.30E+06
1218	232538	21929.4	-0.246	79.97	60.49	-0.05	39.97	23.03	39.46	0.0132	1.31E+06
1220	232372	21908.1	-0.249	80.11	60.57	0.01	39.92	23.00	39.68	0.0132	1.31E+06
1222	232204	21886.7	-0.253	80.26	60.59	0.01	39.93	22.97	39.90	0.0131	1.32E+06
1224	232033	21865.3	-0.256	80.41	60.59	0.03	40.03	22.94	40.13	0.0131	1.33E+06
1226	231859	21843.5	-0.259	80.55	60.41	0.09	40.10	22.90	40.35	0.0130	1.34E+06
1228	231682	21822.5	-0.262	80.70	60.00	0.01	40.05	22.87	40.58	0.0130	1.35E+06
1230	231503	21802.3	-0.265	80.85	59.68	0.03	40.06	22.84	40.82	0.0129	1.35E+06
1232	231322	21782.1	-0.268	81.00	59.36	0.06	40.13	22.81	41.05	0.0129	1.36E+06
1234	231138	21761.6	-0.270	81.14	59.01	0.09	40.17	22.77	41.29	0.0128	1.37E+06
1236	230953	21741.0	-0.272	81.29	58.50	0.08	40.15	22.74	41.54	0.0128	1.38E+06
1238	230766	21720.2	-0.274	81.44	57.86	0.05	40.13	22.71	41.79	0.0127	1.39E+06
1240	230579	21699.1	-0.274	81.59	57.15	0.02	40.18	22.68	42.05	0.0127	1.40E+06
1242	230391	21678.1	-0.274	81.74	56.44	0.06	40.09	22.64	42.30	0.0126	1.40E+06
1244	230203	21657.4	-0.274	81.88	55.89	0.02	39.97	22.61	42.55	0.0126	1.41E+06
1246	230014	21636.6	-0.274	82.03	55.43	0.02	39.99	22.58	42.80	0.0125	1.42E+06
1248	229826	21615.6	-0.273	82.18	55.10	-0.00	40.00	22.54	43.06	0.0125	1.43E+06
1250	229639	21594.4	-0.272	82.33	55.12	0.01	40.01	22.51	43.31	0.0124	1.44E+06
1252	229453	21572.4	-0.270	82.48	55.13	0.02	39.99	22.48	43.57	0.0124	1.45E+06
1254	229267	21550.5	-0.269	82.63	54.98	0.03	39.96	22.44	43.82	0.0123	1.46E+06
1256	229083	21528.4	-0.266	82.78	54.40	-0.02	39.77	22.41	44.07	0.0123	1.46E+06
1258	228901	21505.8	-0.263	82.93	54.21	0.02	39.68	22.38	44.32	0.0122	1.47E+06
1260	228722	21483.6	-0.260	83.08	53.87	-0.01	39.48	22.34	44.57	0.0122	1.48E+06
1262	228543	21461.9	-0.258	83.23	53.39	-0.07	39.30	22.31	44.82	0.0121	1.49E+06
1264	228367	21439.8	-0.254	83.38	53.21	-0.07	39.28	22.28	45.06	0.0121	1.50E+06
1266	228194	21416.9	-0.250	83.53	53.36	0.03	39.31	22.24	45.30	0.0120	1.51E+06
1268	228024	21393.8	-0.246	83.68	53.36	0.03	39.20	22.21	45.52	0.0120	1.52E+06
1270	227856	21370.8	-0.242	83.83	53.31	0.03	38.96	22.17	45.74	0.0119	1.52E+06
1272	227691	21348.1	-0.238	83.99	53.17	0.03	38.82	22.14	45.96	0.0119	1.53E+06
1274	227529	21325.4	-0.235	84.14	52.93	-0.01	38.78	22.11	46.18	0.0118	1.54E+06
1276	227369	21302.6	-0.231	84.29	52.75	-0.00	38.87	22.07	46.39	0.0118	1.55E+06
1278	227212	21279.6	-0.227	84.44	52.55	-0.03	38.86	22.04	46.60	0.0118	1.55E+06
1280	227057	21256.6	-0.224	84.59	52.67	-0.09	38.82	22.01	46.80	0.0117	1.56E+06
1282	226905	21233.6	-0.220	84.75	52.91	-0.10	38.80	21.98	47.00	0.0117	1.57E+06
1284	226755	21210.5	-0.218	84.90	53.46	-0.12	38.80	21.94	47.20	0.0116	1.58E+06
1286	226606	21187.4	-0.216	85.05	54.07	-0.10	38.89	21.91	47.39	0.0116	1.58E+06
1288	226458	21164.1	-0.215	85.21	54.72	-0.10	39.02	21.88	47.58	0.0116	1.59E+06
1290	226310	21140.5	-0.215	85.36	55.49	-0.08	39.16	21.85	47.77	0.0115	1.60E+06
1292	226162	21116.7	-0.216	85.52	56.01	-0.00	39.20	21.81	47.96	0.0115	1.60E+06
1294	226013	21092.8	-0.216	85.67	56.29	-0.02	39.17	21.78	48.15	0.0114	1.61E+06
1296	225863	21068.8	-0.218	85.83	59.24	-0.48	39.26	21.75	48.35	0.0114	1.62E+06
1298	225709	21044.4	-0.226	85.99	61.50	0.27	39.29	21.71	48.54	0.0114	1.63E+06
1300	225549	21020.0	-0.233	86.15	60.24	-1.18	39.13	21.68	48.74	0.0113	1.63E+06
1302	225385	20995.6	-0.240	86.31	61.44	-0.46	39.17	21.64	48.95	0.0113	1.64E+06
1304	225214	20971.2	-0.249	86.47	62.08	-0.13	39.96	21.61	49.18	0.0112	1.65E+06
1306	225036	20944.3	-0.257	86.64	62.52	-0.04	40.07	21.57	49.41	0.0112	1.66E+06
1308	224852	20920.1	-0.268	86.80	62.90	-0.02	39.00	21.53	49.67	0.0111	1.67E+06
1310	224660	20895.8	-0.279	86.96	63.29	-0.02	39.44	21.50	49.94	0.0111	1.68E+06
1312	224459	20870.7	-0.292	87.13	62.04	0.75	39.85	21.46	50.23	0.0111	1.69E+06
1314	224250	20844.9	-0.297	87.29	57.27	0.01	39.97	21.42	50.53	0.0110	1.70E+06
1316	224040	20819.1	-0.298	87.45	55.02	-0.24	39.74	21.38	50.84	0.0110	1.71E+06
1318	223829	20793.8	-0.298	87.61	53.78	-0.34	39.37	21.34	51.15	0.0109	1.72E+06
1320	223619	20768.5	-0.297	87.77	53.28	-0.32	39.30	21.31	51.46	0.0109	1.73E+06

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
1322	223409	20742.3	-0.294	87.93	53.12	-0.26	39.38	21.27	51.77	0.0108	1.74E+06
1324	223202	20715.7	-0.292	88.09	52.91	-0.15	39.35	21.23	52.08	0.0108	1.75E+06
1326	222996	20689.2	-0.289	88.25	52.22	-0.12	39.19	21.19	52.38	0.0107	1.76E+06
1328	222793	20662.8	-0.285	88.41	51.34	-0.20	39.05	21.15	52.68	0.0107	1.77E+06
1330	222593	20636.4	-0.280	88.56	50.95	-0.30	39.07	21.11	52.98	0.0106	1.79E+06
1332	222396	20609.7	-0.276	88.72	50.86	-0.27	39.15	21.08	53.27	0.0106	1.80E+06
1334	222202	20583.0	-0.271	88.88	50.86	-0.28	39.13	21.04	53.55	0.0105	1.81E+06
1336	222011	20556.1	-0.267	89.04	51.04	-0.25	39.10	21.00	53.83	0.0105	1.82E+06
1338	221823	20529.2	-0.263	89.20	51.31	-0.26	39.11	20.96	54.10	0.0104	1.83E+06
1340	221638	20501.9	-0.259	89.36	51.67	-0.28	39.16	20.92	54.36	0.0104	1.84E+06
1342	221455	20474.3	-0.256	89.52	52.13	-0.29	39.20	20.89	54.62	0.0104	1.85E+06
1344	221274	20446.5	-0.253	89.69	52.58	-0.23	39.20	20.85	54.87	0.0103	1.86E+06
1346	221095	20418.5	-0.251	89.85	52.98	-0.20	39.16	20.81	55.12	0.0103	1.87E+06
1348	220917	20390.5	-0.249	90.01	53.41	-0.19	39.15	20.77	55.37	0.0102	1.87E+06
1350	220740	20362.3	-0.249	90.18	53.87	-0.17	39.18	20.73	55.62	0.0102	1.88E+06
1352	220563	20334.0	-0.249	90.34	54.38	-0.13	39.21	20.69	55.87	0.0102	1.89E+06
1354	220385	20305.5	-0.249	90.51	54.56	-0.06	39.22	20.66	56.12	0.0101	1.90E+06
1356	220207	20276.9	-0.250	90.67	54.46	-0.10	39.21	20.62	56.37	0.0101	1.91E+06
1358	220028	20248.4	-0.251	90.84	54.30	-0.13	39.18	20.58	56.62	0.0100	1.92E+06
1360	219848	20219.4	-0.252	91.01	54.07	-0.20	39.18	20.54	56.87	0.0100	1.93E+06
1362	219668	20188.5	-0.252	91.17	54.00	-0.18	39.22	20.49	57.07	0.0100	1.94E+06
1364	219487	20156.8	-0.253	91.34	54.00	-0.18	39.25	20.45	57.26	0.0099	1.95E+06
1366	219306	20125.3	-0.254	91.51	54.07	-0.18	39.21	20.40	57.45	0.0099	1.95E+06
1368	219123	20093.8	-0.256	91.68	54.21	-0.15	39.18	20.35	57.64	0.0099	1.96E+06
1370	218939	20062.2	-0.258	91.85	54.35	-0.24	39.29	20.30	57.83	0.0098	1.97E+06
1372	218754	20030.3	-0.260	92.02	54.86	-0.20	39.42	20.25	58.03	0.0098	1.98E+06
1374	218566	19997.9	-0.263	92.19	55.45	-0.15	39.53	20.21	58.22	0.0097	1.98E+06
1376	218376	19965.2	-0.267	92.36	55.78	-0.09	39.56	20.16	58.42	0.0097	1.99E+06
1378	218183	19932.7	-0.272	92.53	55.83	-0.14	39.51	20.11	58.63	0.0097	2.00E+06
1380	217987	19900.1	-0.277	92.70	55.90	-0.19	39.54	20.06	58.84	0.0096	2.01E+06
1382	217788	19867.2	-0.282	92.88	55.98	-0.20	39.62	20.01	59.08	0.0096	2.01E+06
1384	217584	19834.1	-0.287	93.05	56.20	-0.16	39.73	19.96	59.29	0.0096	2.02E+06
1386	217377	19800.5	-0.292	93.23	56.44	-0.14	39.78	19.90	59.50	0.0095	2.03E+06
1388	217167	19766.7	-0.298	93.40	56.67	-0.11	39.78	19.85	59.76	0.0095	2.04E+06
1390	216952	19732.8	-0.304	93.58	56.89	-0.08	39.77	19.80	60.01	0.0094	2.05E+06
1392	216733	19698.5	-0.311	93.76	57.03	-0.00	39.81	19.75	60.26	0.0094	2.06E+06
1394	216509	19664.0	-0.317	93.93	56.76	-0.04	39.83	19.69	60.53	0.0094	2.07E+06
1396	216280	19629.3	-0.323	94.11	56.46	-0.06	39.84	19.64	60.80	0.0093	2.08E+06
1398	216048	19594.3	-0.329	94.29	56.15	-0.07	39.84	19.59	61.09	0.0093	2.09E+06
1400	215812	19559.2	-0.334	94.47	55.85	-0.05	39.81	19.53	61.38	0.0092	2.10E+06
1402	215573	19523.9	-0.339	94.65	55.55	-0.05	39.81	19.48	61.68	0.0092	2.11E+06
1404	215331	19488.4	-0.343	94.83	55.25	-0.05	39.84	19.42	61.98	0.0091	2.12E+06
1406	215086	19452.6	-0.347	95.01	54.94	-0.05	39.86	19.37	62.29	0.0091	2.13E+06
1408	214838	19416.6	-0.351	95.19	54.60	-0.06	39.87	19.31	62.61	0.0091	2.14E+06
1410	214589	19380.4	-0.353	95.37	54.29	-0.06	39.87	19.26	62.93	0.0090	2.15E+06
1412	214338	19344.0	-0.356	95.55	53.99	-0.07	39.86	19.20	63.26	0.0090	2.16E+06
1414	214085	19307.5	-0.358	95.73	53.76	-0.07	39.86	19.15	63.58	0.0089	2.18E+06
1416	213831	19270.8	-0.360	95.91	53.49	-0.09	39.89	19.09	63.92	0.0089	2.19E+06
1418	213576	19233.9	-0.361	96.09	53.25	-0.14	39.92	19.04	64.25	0.0088	2.20E+06
1420	213320	19196.7	-0.363	96.27	53.54	-0.17	39.92	18.98	64.60	0.0088	2.21E+06
1422	213063	19159.4	-0.365	96.45	54.05	-0.11	39.88	18.92	64.93	0.0087	2.22E+06
1424	212805	19122.0	-0.368	96.64	54.51	-0.02	39.85	18.87	65.26	0.0087	2.24E+06
1426	212544	19084.3	-0.374	96.82	54.53	0.32	39.90	18.81	65.60	0.0087	2.25E+06
1428	212279	19046.3	-0.377	97.01	49.06	0.87	40.06	18.75	65.97	0.0086	2.26E+06
1430	212018	19007.2	-0.363	97.18	38.94	0.07	40.21	18.70	66.31	0.0086	2.27E+06

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
1432	211772	18968.0	-0.334	97.33	29.17	-0.03	40.12	18.64	66.62	0.0085	2.29E+06
1434	211548	18928.8	-0.296	97.47	19.57	0.05	40.01	18.59	66.87	0.0085	2.30E+06
1436	211352	18889.6	-0.250	97.59	9.86	0.07	39.90	18.53	67.06	0.0085	2.30E+06
1438	211188	18850.4	-0.201	97.68	-0.03	0.05	39.97	18.48	67.19	0.0084	2.31E+06
1440	211056	18810.9	-0.151	97.75	-10.00	0.03	40.03	18.44	67.20	0.0084	2.32E+06
1442	210957	18771.3	-0.106	97.80	-20.02	0.02	40.05	18.39	67.16	0.0084	2.32E+06
1444	210884	18731.6	-0.068	97.83	-30.05	0.04	40.06	18.35	67.06	0.0084	2.32E+06
1446	210833	18691.9	-0.043	97.83	-40.18	0.04	40.10	18.30	66.88	0.0084	2.32E+06
1448	210794	18652.2	-0.032	97.82	-50.38	-0.02	40.19	18.26	66.69	0.0083	2.31E+06
1450	210756	18612.3	-0.040	97.79	-60.41	-0.11	40.24	18.22	66.49	0.0083	2.31E+06
1452	210706	18572.7	-0.069	97.76	-66.72	-0.59	40.26	18.18	66.31	0.0083	2.31E+06
1454	210635	18532.9	-0.103	97.72	-68.60	-0.27	40.25	18.13	66.23	0.0083	2.31E+06
1456	210541	18493.2	-0.141	97.67	-70.10	-0.14	40.41	18.09	66.14	0.0083	2.31E+06
1458	210422	18452.9	-0.182	97.63	-71.11	-0.16	40.65	18.04	66.14	0.0083	2.31E+06
1460	210276	18411.9	-0.224	97.59	-71.48	-0.11	40.87	17.99	66.17	0.0082	2.32E+06
1462	210103	18370.3	-0.267	97.54	-71.68	-0.08	41.08	17.94	66.29	0.0082	2.32E+06
1464	209904	18328.2	-0.310	97.49	-71.28	-0.12	41.19	17.88	66.46	0.0082	2.33E+06
1466	209677	18285.1	-0.353	97.44	-70.46	-0.09	41.28	17.83	66.68	0.0081	2.34E+06
1468	209425	18240.1	-0.393	97.39	-69.50	-0.09	41.61	17.77	66.96	0.0081	2.36E+06
1470	209148	18194.2	-0.431	97.33	-68.45	-0.13	41.71	17.72	67.29	0.0081	2.37E+06
1472	208849	18147.9	-0.467	97.27	-67.22	-0.16	41.71	17.66	67.67	0.0080	2.39E+06
1474	208528	18101.3	-0.501	97.21	-65.71	-0.14	41.70	17.60	68.11	0.0080	2.41E+06
1476	208189	18054.2	-0.531	97.15	-64.08	-0.10	41.70	17.53	68.59	0.0079	2.43E+06
1478	207833	18006.7	-0.557	97.09	-62.62	-0.07	41.70	17.47	69.11	0.0078	2.45E+06
1480	207462	17958.7	-0.580	97.03	-61.41	-0.02	41.70	17.41	69.66	0.0078	2.47E+06
1482	207078	17910.2	-0.601	96.97	-60.26	-0.03	41.69	17.34	70.25	0.0077	2.49E+06
1484	206684	17861.3	-0.619	96.91	-59.22	0.03	41.69	17.28	70.87	0.0077	2.52E+06
1486	206279	17812.0	-0.636	96.85	-58.32	0.04	41.68	17.21	71.51	0.0076	2.54E+06
1488	205867	17762.2	-0.650	96.79	-57.37	0.08	41.67	17.15	72.17	0.0075	2.57E+06
1490	205448	17712.0	-0.661	96.73	-56.59	0.13	41.68	17.08	72.86	0.0075	2.60E+06
1492	205024	17660.9	-0.671	96.67	-56.02	0.13	41.67	17.01	73.58	0.0074	2.63E+06
1494	204595	17609.2	-0.679	96.60	-55.55	0.08	41.65	16.94	74.28	0.0074	2.65E+06
1496	204164	17557.2	-0.685	96.54	-54.77	0.06	41.56	16.88	74.99	0.0073	2.68E+06
1498	203731	17504.9	-0.689	96.47	-53.97	0.06	41.45	16.81	75.70	0.0072	2.71E+06
1500	203298	17452.5	-0.691	96.40	-53.18	0.07	41.34	16.74	76.42	0.0072	2.74E+06
1502	202866	17403.8	-0.691	96.34	-52.50	0.12	41.28	16.68	77.27	0.0071	2.78E+06
1504	202435	17356.1	-0.689	96.28	-52.05	0.11	41.25	16.64	78.16	0.0070	2.82E+06
1506	202007	17307.9	-0.686	96.22	-51.63	0.13	41.23	16.59	79.08	0.0070	2.86E+06
1508	201582	17259.4	-0.682	96.15	-51.33	0.20	41.15	16.54	79.96	0.0069	2.89E+06
1510	201162	17210.6	-0.677	96.09	-51.21	0.25	41.06	16.49	80.84	0.0069	2.93E+06
1512	200746	17161.6	-0.671	96.03	-51.32	0.28	40.99	16.44	81.71	0.0068	2.97E+06
1514	200335	17112.0	-0.666	95.96	-51.72	0.30	40.98	16.39	82.57	0.0067	3.01E+06
1516	199928	17061.9	-0.661	95.89	-52.45	0.26	40.96	16.33	83.41	0.0067	3.05E+06
1518	199525	17011.5	-0.659	95.81	-51.74	-0.14	40.87	16.28	84.25	0.0066	3.09E+06
1520	199126	16960.9	-0.648	95.74	-48.97	0.54	40.81	16.23	85.08	0.0066	3.13E+06
1522	198737	16909.7	-0.635	95.67	-50.09	-0.93	40.67	16.18	85.88	0.0065	3.17E+06
1524	198356	16858.2	-0.622	95.59	-48.50	0.05	40.65	16.13	86.65	0.0064	3.20E+06
1526	197984	16806.4	-0.606	95.52	-47.84	0.23	41.06	16.08	87.39	0.0064	3.24E+06
1528	197626	16751.4	-0.584	95.44	-47.56	0.27	40.67	16.02	88.05	0.0063	3.28E+06
1530	197281	16699.6	-0.565	95.37	-47.68	0.23	40.11	15.97	88.71	0.0063	3.31E+06
1532	196947	16647.0	-0.546	95.29	-47.89	0.20	40.31	15.92	89.32	0.0063	3.34E+06
1534	196626	16593.8	-0.528	95.21	-50.14	0.63	40.30	15.86	89.88	0.0062	3.37E+06
1536	196314	16540.3	-0.522	95.13	-53.89	0.03	40.24	15.81	90.38	0.0062	3.40E+06
1538	196004	16487.0	-0.522	95.03	-55.68	0.15	40.12	15.75	90.88	0.0061	3.43E+06
1540	195694	16433.7	-0.528	94.94	-57.27	0.18	40.10	15.70	91.37	0.0061	3.46E+06

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
1542	195379	16380.2	-0.540	94.84	-58.73	0.15	40.12	15.64	91.89	0.0060	3.49E+06
1544	195058	16326.4	-0.555	94.73	-59.92	0.12	40.17	15.59	92.42	0.0060	3.52E+06
1546	194728	16272.4	-0.574	94.62	-60.74	0.09	40.22	15.53	92.98	0.0060	3.55E+06
1548	194389	16218.0	-0.595	94.51	-61.20	0.13	40.27	15.48	93.58	0.0059	3.58E+06
1550	194038	16163.3	-0.617	94.40	-61.69	0.14	40.34	15.42	94.21	0.0059	3.62E+06
1552	193676	16108.1	-0.641	94.28	-61.99	0.07	40.40	15.36	94.88	0.0058	3.65E+06
1554	193302	16052.3	-0.666	94.16	-61.96	0.12	40.45	15.30	95.59	0.0058	3.69E+06
1556	192915	15995.4	-0.690	94.04	-61.95	0.12	40.50	15.24	96.29	0.0057	3.73E+06
1558	192517	15938.2	-0.715	93.92	-61.94	0.08	40.53	15.18	97.03	0.0057	3.77E+06
1560	192106	15880.5	-0.739	93.79	-61.88	0.04	40.57	15.11	97.81	0.0056	3.81E+06
1562	191684	15822.1	-0.763	93.67	-61.68	0.01	40.61	15.05	98.63	0.0056	3.85E+06
1564	191251	15762.5	-0.785	93.53	-61.27	-0.08	40.64	14.98	99.48	0.0055	3.89E+06
1566	190809	15701.9	-0.804	93.40	-60.21	-0.15	40.64	14.92	100.35	0.0055	3.94E+06
1568	190359	15640.7	-0.817	93.26	-58.50	-0.19	40.55	14.85	101.25	0.0054	3.99E+06
1570	189907	15578.8	-0.822	93.13	-56.22	-0.21	40.40	14.78	102.17	0.0054	4.04E+06
1572	189456	15516.9	-0.817	93.00	-53.81	-0.11	40.25	14.72	103.13	0.0053	4.09E+06
1574	189013	15454.7	-0.805	92.87	-52.52	-0.08	40.11	14.66	104.07	0.0053	4.14E+06
1576	188578	15392.6	-0.791	92.74	-51.84	-0.06	39.95	14.60	104.98	0.0052	4.19E+06
1578	188154	15330.7	-0.775	92.61	-51.49	-0.03	39.85	14.53	105.86	0.0052	4.24E+06
1580	187740	15268.7	-0.758	92.48	-51.45	0.03	39.80	14.47	106.69	0.0051	4.29E+06
1582	187337	15206.4	-0.742	92.35	-52.07	0.01	39.74	14.41	107.48	0.0051	4.34E+06
1584	186944	15144.2	-0.729	92.21	-52.69	0.02	39.68	14.35	108.24	0.0050	4.39E+06
1586	186558	15081.8	-0.719	92.07	-53.51	0.07	39.64	14.28	108.90	0.0050	4.43E+06
1588	186180	15019.1	-0.710	91.93	-54.38	0.12	39.58	14.22	109.48		4.47E+06
1590	185807	14955.8	-0.705	91.78	-55.45	0.11	39.60	14.15	110.03		4.50E+06
1592	185437	14892.1	-0.704	91.62	-56.48	0.06	39.58	14.08	110.56		4.54E+06
1594	185069	14828.2	-0.706	91.46	-57.21	0.05	39.51	14.01	111.08		4.58E+06
1596	184700	14763.8	-0.711	91.29	-57.94	0.02	39.47	13.94	111.59		4.61E+06
1598	184331	14698.7	-0.718	91.12	-57.83	-0.17	39.51	13.87	112.08		4.65E+06
1600	183961	14632.9	-0.718	90.95	-55.93	-0.03	39.51	13.80	112.57		4.69E+06
1602	183595	14567.0	-0.711	90.78	-54.07	-0.04	39.49	13.73	113.04		4.72E+06
1604	183237	14500.7	-0.696	90.61	-52.16	0.00	39.45	13.66	113.47		4.76E+06
1606	182890	14434.1	-0.673	90.45	-50.43	0.03	39.38	13.59	113.85		4.79E+06
1608	182558	14367.7	-0.644	90.29	-49.13	0.07	39.29	13.52	114.17		4.82E+06
1610	182243	14301.5	-0.613	90.14	-48.46	0.09	39.20	13.45	114.42		4.85E+06
1612	181946	14235.6	-0.580	89.98	-48.02	0.16	39.12	13.38	114.60		4.88E+06
1614	181667	14169.9	-0.547	89.83	-48.36	0.18	39.07	13.32	114.70		4.90E+06
1616	181405	14104.4	-0.518	89.67	-48.99	0.14	39.00	13.25	114.73		4.93E+06
1618	181157	14039.3	-0.493	89.51	-49.76	0.21	38.94	13.19	114.69		4.94E+06
1620	180922	13974.4	-0.472	89.34	-50.88	0.19	38.92	13.12	114.65		4.96E+06
1622	180697	13909.6	-0.458	89.17	-52.09	0.15	38.93	13.06	114.50		4.98E+06
1624	180479	13845.0	-0.449	89.00	-53.35	0.15	38.94	12.99	114.33		4.99E+06
1626	180265	13780.4	-0.447	88.82	-54.41	0.11	38.99	12.93	114.14		5.00E+06
1628	180052	13716.0	-0.450	88.64	-55.13	0.14	39.01	12.86	113.96		5.02E+06
1630	179838	13651.5	-0.456	88.45	-55.83	0.16	39.05	12.80	113.77		5.03E+06
1632	179621	13586.9	-0.467	88.26	-56.48	0.07	39.11	12.74	113.59		5.04E+06
1634	179400	13522.3	-0.480	88.07	-56.68	0.12	39.14	12.67	113.43		5.06E+06
1636	179173	13457.6	-0.495	87.87	-56.93	0.07	39.18	12.61	113.24		5.07E+06
1638	178941	13393.0	-0.512	87.67	-57.07	0.06	39.22	12.54	113.11		5.09E+06
1640	178701	13328.5	-0.530	87.48	-57.10	0.05	39.26	12.48	112.99		5.11E+06
1642	178455	13263.8	-0.550	87.28	-56.97	0.06	39.33	12.41	112.91		5.12E+06
1644	178200	13199.1	-0.569	87.08	-56.75	0.08	39.39	12.35	112.84		5.14E+06
1646	177939	13134.4	-0.588	86.88	-56.44	0.09	39.44	12.28	112.80		5.16E+06
1648	177670	13069.2	-0.606	86.68	-56.15	0.05	39.49	12.22	112.78		5.19E+06
1650	177395	13003.7	-0.623	86.47	-55.74	0.06	39.52	12.15	112.77		5.21E+06

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
1652	177115	12938.2	-0.638	86.27	-55.30	0.04	39.54	12.09	112.78		5.23E+06
1654	176830	12872.9	-0.652	86.07	-54.67	0.04	39.52	12.02	112.77		5.25E+06
1656	176541	12807.5	-0.664	85.86	-53.89	0.11	39.52	11.95	112.74		5.27E+06
1658	176249	12742.2	-0.673	85.66	-53.48	0.10	39.55	11.88	112.71		5.30E+06
1660	175954	12677.0	-0.682	85.45	-53.01	0.08	39.55	11.82	112.68		5.32E+06
1662	175658	12611.9	-0.690	85.25	-52.45	0.11	39.56	11.75	112.66		5.34E+06
1664	175360	12546.8	-0.696	85.05	-51.92	0.16	39.63	11.68	112.63		5.36E+06
1666	175062	12481.0	-0.700	84.85	-51.66	0.17	39.90	11.61	112.59		5.38E+06
1668	174765	12414.8	-0.703	84.64	-51.50	0.15	39.90	11.54	112.53		5.40E+06
1670	174468	12348.8	-0.707	84.43	-51.36	0.15	39.88	11.48	112.47		5.42E+06
1672	174170	12283.0	-0.712	84.23	-51.20	0.14	39.85	11.41	112.41		5.44E+06
1674	173873	12217.4	-0.716	84.02	-50.98	0.15	39.82	11.34	112.34		5.46E+06
1676	173575	12152.0	-0.721	83.81	-50.84	0.14	39.75	11.27	112.28		5.48E+06
1678	173277	12087.2	-0.726	83.60	-50.79	0.22	39.73	11.21	112.25		5.51E+06
1680	172979	12022.2	-0.733	83.39	-51.19	0.20	39.73	11.14	112.21		5.53E+06
1682	172679	11957.2	-0.742	83.18	-51.78	0.16	39.73	11.08	112.17		5.55E+06
1684	172377	11892.4	-0.756	82.96	-52.23	0.12	39.71	11.01	112.13		5.58E+06
1686	172070	11827.6	-0.771	82.74	-52.51	0.12	39.70	10.95	112.11		5.60E+06
1688	171759	11762.7	-0.789	82.51	-52.81	0.12	39.72	10.88	112.10		5.63E+06
1690	171441	11697.7	-0.809	82.28	-53.13	0.12	39.72	10.82	112.10		5.66E+06
1692	171118	11632.4	-0.830	82.05	-53.52	0.08	39.70	10.75	112.11		5.69E+06
1694	170787	11567.2	-0.854	81.81	-53.59	0.03	39.68	10.68	112.15		5.72E+06
1696	170448	11502.0	-0.878	81.57	-53.33	0.04	39.64	10.62	112.21		5.75E+06
1698	170103	11437.2	-0.901	81.33	-52.94	0.01	39.60	10.56	112.48		5.80E+06
1700	169751	11372.7	-0.923	81.09	-52.28	0.04	39.56	10.51	112.83		5.85E+06
1702	169393	11308.3	-0.942	80.85	-51.82	0.05	39.53	10.45	113.20		5.91E+06
1704	169030	11243.9	-0.960	80.60	-51.35	0.07	39.50	10.40	113.59		5.97E+06
1706	168662	11179.6	-0.976	80.36	-50.91	0.06	39.46	10.35	114.00		6.03E+06
1708	168292	11115.2	-0.990	80.11	-50.69	0.10	39.43	10.29	114.41		6.09E+06
1710	167918	11050.7	-1.004	79.87	-50.67	0.02	39.38	10.24	114.84		6.16E+06
1712	167541	10986.2	-1.019	79.61	-50.51	0.03	39.32	10.19	115.27		6.22E+06
1714	167162	10921.7	-1.032	79.36	-50.27	0.07	39.26	10.13	115.71		6.29E+06
1716	166780	10856.0	-1.045	79.11	-50.09	0.07	39.21	10.07	116.01		6.34E+06
1718	166396	10789.5	-1.056	78.85	-50.05	0.13	39.16	10.01	116.26		6.40E+06
1720	166010	10723.2	-1.069	78.60	-50.42	0.11	39.09	9.95	116.51		6.45E+06
1722	165622	10657.1	-1.085	78.33	-50.84	0.00	38.96	9.88	116.77		6.50E+06
1724	165229	10591.1	-1.104	78.06	-51.06	0.02	38.87	9.82	117.04		6.56E+06
1726	164833	10525.3	-1.124	77.79	-51.31	0.02	38.80	9.76	117.32		6.61E+06
1728	164431	10459.6	-1.149	77.52	-51.20	-0.16	38.78	9.70	117.63		6.67E+06
1730	164023	10393.8	-1.163	77.25	-47.52	0.01	38.75	9.64	117.94		6.73E+06
1732	163618	10328.0	-1.155	77.00	-45.22	0.13	38.64	9.57	118.24		6.79E+06
1734	163220	10263.0	-1.139	76.75	-42.89	0.05	38.53	9.51	118.53		6.85E+06
1736	162833	10198.2	-1.111	76.52	-40.50	0.17	38.39	9.45	118.77		6.91E+06
1738	162460	10134.1	-1.075	76.30	-39.15	0.19	38.18	9.39	118.95		6.96E+06
1740	162103	10070.7	-1.037	76.09	-38.68	0.21	38.01	9.34	119.07		7.01E+06
1742	161761	10007.9	-1.002	75.87	-39.07	0.18	37.90	9.28	119.12		7.06E+06
1744	161433	9945.5	-0.972	75.65	-39.95	0.09	37.81	9.22	119.11		7.10E+06
1746	161116	9883.5	-0.950	75.42	-37.71	-0.67	37.82	9.16	119.05		7.14E+06
1748	160813	9821.1	-0.896	75.23	-28.09	0.07	37.88	9.10	118.91		7.18E+06
1750	160537	9759.1	-0.808	75.10	-18.65	-0.08	37.71	9.05	118.65		7.21E+06
1752	160296	9698.3	-0.702	75.05	-8.62	-0.14	37.55	8.99	118.28		7.23E+06
1754	160094	9637.8	-0.586	75.06	1.86	-0.09	37.55	8.94	117.81		7.25E+06
1756	159932	9577.6	-0.476	75.16	12.42	-0.06	37.53	8.88	117.11		7.26E+06
1758	159804	9517.9	-0.387	75.33	22.82	-0.13	37.49	8.83	116.25		7.25E+06
1760	159701	9458.8	-0.332	75.57	33.35	-0.06	37.48	8.78	115.26		7.23E+06

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
1762	159609	9400.2	-0.322	75.88	43.67	-0.14	37.52	8.72	114.31		7.22E+06
1764	159512	9341.8	-0.371	76.25	53.38	0.32	37.51	8.67	113.33		7.20E+06
1766	159390	9284.4	-0.463	76.64	56.77	0.24	37.35	8.62	112.50		7.20E+06
1768	159237	9227.8	-0.569	77.03	58.59	0.02	37.47	8.57	111.82		7.20E+06
1770	159049	9171.0	-0.686	77.44	59.76	0.13	37.61	8.52	111.30		7.21E+06
1772	158822	9114.2	-0.809	77.85	60.10	0.08	37.75	8.47	110.94		7.24E+06
1774	158558	9057.4	-0.934	78.26	59.64	0.13	37.81	8.42	110.75		7.28E+06
1776	158256	9000.4	-1.055	78.67	58.54	0.20	37.86	8.37	110.71		7.32E+06
1778	157918	8943.3	-1.164	79.07	55.61	0.22	37.80	8.32	110.82		7.38E+06
1780	157553	8886.4	-1.251	79.47	51.97	0.08	37.70	8.27	111.06		7.45E+06
1782	157165	8829.1	-1.315	79.85	48.44	0.11	37.59	8.22	111.35		7.52E+06
1784	156763	8771.3	-1.360	80.21	44.78	0.15	37.43	8.16	111.58		7.59E+06
1786	156353	8713.6	-1.383	80.55	41.17	0.13	37.13	8.11	111.84		7.66E+06
1788	155941	8656.4	-1.392	80.88	38.71	0.09	36.74	8.05	112.11		7.72E+06
1790	155530	8600.0	-1.395	81.19	37.27	0.13	36.48	8.00	112.39		7.79E+06
1792	155121	8543.4	-1.390	81.51	36.80	0.17	36.48	7.95	112.64		7.86E+06
1794	154717	8486.1	-1.382	81.82	36.61	0.30	36.41	7.89	112.85		7.93E+06
1796	154317	8430.0	-1.376	82.14	35.20	0.42	35.98	7.84	113.06		7.99E+06
1798	153922	8375.1	-1.365	82.43	34.00	0.07	35.67	7.79	113.29		8.06E+06
1800	153532	8321.0	-1.359	82.75	35.90	0.05	35.52	7.74	113.62		8.14E+06
1802	153144	8266.9	-1.370	83.08	39.31	0.41	35.41	7.70	113.95		8.23E+06
1804	152753	8213.2	-1.395	83.44	40.99	0.32	35.30	7.65	114.29		8.31E+06
1806	152355	8159.5	-1.428	83.80	42.19	0.24	35.21	7.60	114.66		8.40E+06
1808	151950	8105.8	-1.465	84.17	43.01	0.28	35.16	7.56	115.05		8.49E+06
1810	151536	8052.1	-1.505	84.55	42.97	0.24	35.03	7.51	115.48		8.59E+06
1812	151113	7998.9	-1.546	84.93	42.57	0.22	34.84	7.47	115.96		8.69E+06
1814	150681	7946.2	-1.586	85.31	41.93	0.24	34.75	7.42	116.48		8.79E+06
1816	150242	7894.4	-1.623	85.68	41.39	0.16	34.65	7.38	117.09		8.91E+06
1818	149795	7842.7	-1.658	86.05	41.14	0.09	34.56	7.33	117.73		9.02E+06
1820	149341	7790.8	-1.689	86.43	40.72	0.04	34.44	7.29	118.39		9.14E+06
1822	148882	7739.2	-1.718	86.80	40.02	0.03	34.28	7.25	119.07		9.27E+06
1824	148419	7687.9	-1.743	87.16	39.00	0.07	34.08	7.20	119.79		9.39E+06
1826	147952	7636.9	-1.761	87.53	38.04	-0.01	33.89	7.16	120.52		9.52E+06
1828	147484	7585.8	-1.776	87.89	37.86	0.04	33.75	7.12	121.25		9.66E+06
1830	147015	7534.9	-1.790	88.25	37.38	0.01	33.47	7.07	121.96		9.78E+06
1832	146545	7484.4	-1.804	88.61	37.03	-0.06	33.26	7.03	122.67		9.91E+06
1834	146075	7434.1	-1.818	88.97	37.42	0.04	33.16	6.98	123.39		1.00E+07
1836	145604	7383.6	-1.833	89.35	38.06	0.07	32.99	6.94	124.10		1.02E+07
1838	145131	7333.5	-1.852	89.72	38.51	0.11	32.81	6.89	124.81		1.03E+07
1840	144656	7283.8	-1.875	90.11	38.66	0.14	32.60	6.85	125.55		1.05E+07
1842	144177	7234.6	-1.900	90.49	38.48	0.08	32.42	6.81	126.32		1.06E+07
1844	143695	7185.6	-1.925	90.87	38.68	0.05	32.31	6.76	127.11		1.07E+07
1846	143210	7136.7	-1.952	91.26	39.10	0.10	32.19	6.72	127.93		1.09E+07
1848	142721	7087.9	-1.981	91.66	39.28	0.12	32.07	6.68	128.75		1.11E+07
1850	142228	7039.3	-2.011	92.06	39.33	0.14	31.93	6.64	129.60		1.12E+07
1852	141730	6990.8	-2.041	92.47	39.16	0.10	31.80	6.59	130.47		1.14E+07
1854	141228	6942.3	-2.067	92.87	38.90	-0.01	31.73	6.55	131.36		1.15E+07
1856	140724	6893.8	-2.087	93.28	37.38	-1.19	31.62	6.51	132.28		1.17E+07
1858	140218	6845.4	-2.122	93.71	44.67	0.15	31.69	6.47	133.30		1.19E+07
1860	139702	6797.1	-2.196	94.19	46.36	0.35	31.26	6.43	134.39		1.21E+07
1862	139170	6749.1	-2.273	94.67	46.30	0.11	31.91	6.39	135.58		1.23E+07
1864	138625	6699.9	-2.342	95.17	46.37	0.09	30.63	6.35	136.78		1.25E+07
1866	138065	6654.7	-2.430	95.65	46.29	-0.06	30.47	6.31	138.24		1.28E+07
1868	137489	6608.1	-2.513	96.14	45.88	0.22	30.83	6.27	139.73		1.30E+07
1870	136900	6560.5	-2.571	96.59	42.41	0.17	30.75	6.23	141.10		1.32E+07

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
1872	136305	6513.1	-2.597	97.02	37.24	0.10	30.42	6.19	142.51		1.35E+07
1874	135712	6466.5	-2.591	97.39	33.36	-0.19	30.19	6.14	143.95		1.37E+07
1876	135126	6419.9	-2.573	97.76	32.96	-0.11	29.96	6.10	145.34		1.40E+07
1878	134548	6373.7	-2.559	98.13	33.70	-0.03	29.76	6.06	146.71		1.42E+07
1880	133976	6328.0	-2.550	98.51	34.72	-0.05	29.59	6.02	147.90		1.44E+07
1882	133410	6282.1	-2.544	98.90	35.74	-0.09	29.47	5.97	148.92		1.46E+07
1884	132848	6236.0	-2.539	99.31	36.54	-0.10	29.32	5.92	149.88		1.48E+07
1886	132292	6189.9	-2.538	99.72	36.94	-0.02	29.08	5.87	150.81		1.50E+07
1888	131739	6144.3	-2.539	100.14	37.05	-0.04	28.78	5.83	151.73		1.52E+07
1890	131189	6099.0	-2.544	100.57	37.75	0.09	28.54	5.78	152.63		1.54E+07
1892	130641	6054.0	-2.557	101.02	38.39	0.23	28.29	5.74	153.83		1.56E+07
1894	130094	6009.0	-2.570	101.47	38.56	0.24	28.17	5.70	155.19		1.59E+07
1896	129548	5963.8	-2.582	101.94	38.82	0.23	28.05	5.66	156.52		1.62E+07
1898	129004	5918.2	-2.589	102.42	38.82	0.24	27.84	5.62	157.81		1.64E+07
1900	128463	5872.6	-2.593	102.90	38.59	0.18	27.60	5.59	159.08		1.67E+07
1902	127924	5827.5	-2.597	103.38	38.38	0.17	27.31	5.55	160.33		1.70E+07
1904	127389	5782.6	-2.604	103.86	38.40	0.15	27.11	5.51	161.67		1.73E+07
1906	126856	5737.6	-2.608	104.35	38.53	0.03	26.95	5.48	163.04		1.76E+07
1908	126326	5692.6	-2.614	104.85	39.16	0.10	26.73	5.44	164.37		1.80E+07
1910	125798	5648.0	-2.628	105.36	39.50	0.10	26.53	5.40	165.71		1.83E+07
1912	125271	5603.8	-2.647	105.87	40.07	0.04	26.39	5.37	167.06		1.86E+07
1914	124743	5559.7	-2.674	106.40	41.22	0.04	26.24	5.33	168.40		1.90E+07
1916	124213	5515.1	-2.710	106.96	42.26	0.11	26.17	5.29	169.65		1.93E+07
1918	123679	5469.7	-2.749	107.54	42.49	0.10	26.04	5.25	170.74		1.96E+07
1920	123142	5424.6	-2.791	108.13	42.64	0.16	25.80	5.21	171.86		1.99E+07
1922	122601	5380.1	-2.837	108.72	42.35	0.22	25.60	5.17	173.03		2.02E+07
1924	122055	5335.8	-2.882	109.32	42.86	0.28	25.45	5.13	174.23		2.05E+07
1926	121505	5291.8	-2.936	109.93	43.26	0.36	25.31	5.09	175.48		2.09E+07
1928	120948	5249.2	-2.992	110.53	42.99	0.23	25.25	5.06	176.96		2.12E+07
1930	120386	5208.7	-3.047	111.13	43.00	0.14	25.14	5.02	178.82		2.17E+07
1932	119817	5168.3	-3.104	111.74	43.05	0.12	25.07	4.99	180.73		2.21E+07
1934	119242	5127.7	-3.159	112.36	43.30	0.10	25.02	4.96	182.68		2.26E+07
1936	118662	5087.1	-3.214	112.98	43.47	0.14	24.92	4.92	184.67		2.31E+07
1938	118076	5046.4	-3.267	113.62	43.39	0.11	24.77	4.89	186.71		2.35E+07
1940	117486	5005.6	-3.312	114.26	42.94	-0.04	24.70	4.86	188.76		2.40E+07
1942	116894	4964.7	-3.353	114.90	42.78	-0.08	24.56	4.82	190.83		2.46E+07
1944	116299	4923.8	-3.387	115.55	42.34	-0.09	24.27	4.79	192.91		2.51E+07
1946	115703	4883.3	-3.417	116.19	41.49	-0.09	24.02	4.76	195.03		2.56E+07
1948	115109	4842.6	-3.433	116.84	41.10	0.01	23.77	4.72	197.13		2.62E+07
1950	114516	4802.1	-3.447	117.50	40.76	0.21	23.40	4.69	199.24		2.67E+07
1952	113926	4760.8	-3.457	118.12	40.18	0.15	23.29	4.66	201.50		2.73E+07
1954	113340	4719.7	-3.465	118.73	39.43	-0.07	23.08	4.62	203.74		2.80E+07
1956	112757	4678.9	-3.471	119.35	39.61	-0.03	22.89	4.59	205.96		2.86E+07
1958	112177	4638.4	-3.484	119.97	39.60	-0.07	22.69	4.56	208.17		2.92E+07
1960	111600	4598.3	-3.497	120.58	39.26	-0.27	22.53	4.53	210.38		2.99E+07
1962	111026	4557.3	-3.516	121.22	40.59	-0.09	22.37	4.49	212.23		3.05E+07
1964	110452	4515.6	-3.544	121.88	40.82	-0.08	22.19	4.45	213.73		3.10E+07
1966	109879	4473.6	-3.570	122.55	40.28	0.82	22.08	4.41	215.17		3.15E+07
1968	109311	4431.1	-3.526	123.17	30.80	0.24	21.99	4.37	216.48		3.20E+07
1970	108762	4388.9	-3.399	123.64	21.41	0.19	21.79	4.33	217.60		3.25E+07
1972	108242	4347.2	-3.219	123.95	11.58	0.24	21.52	4.29	218.47		3.29E+07
1974	107756	4307.0	-3.014	124.09	1.92	0.27	21.21	4.25	219.27		3.34E+07
1976	107305	4268.1	-2.815	124.07	-8.11	0.21	21.01	4.22	219.91		3.38E+07
1978	106886	4229.3	-2.647	123.87	-18.06	0.22	20.82	4.18	220.21		3.42E+07
1980	106491	4190.9	-2.543	123.50	-27.96	0.23	20.60	4.15	220.26		3.46E+07

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
1982	106108	4153.1	-2.537	122.98	-38.10	0.04	20.36	4.11	220.22		3.49E+07
1984	105722	4116.2	-2.635	122.34	-43.49	-0.07	20.09	4.08	220.26		3.53E+07
1986	105321	4079.8	-2.780	121.67	-46.15	-0.00	19.97	4.04	220.47		3.57E+07
1988	104902	4043.4	-2.950	120.96	-47.53	0.00	20.01	4.01	220.85		3.61E+07
1990	104462	4006.9	-3.131	120.22	-48.26	-0.05	20.00	3.98	221.39		3.65E+07
1992	104001	3970.7	-3.314	119.48	-47.44	0.06	19.89	3.94	222.15		3.70E+07
1994	103521	3934.3	-3.482	118.73	-47.09	0.03	19.84	3.91	223.05		3.76E+07
1996	103023	3897.5	-3.638	117.97	-46.57	-0.15	19.76	3.88	224.06		3.82E+07
1998	102509	3860.7	-3.775	117.20	-45.03	-0.14	19.61	3.84	225.19		3.88E+07
2000	101985	3823.9	-3.888	116.46	-43.17	-0.13	19.45	3.81	226.40		3.94E+07
2002	101452	3787.6	-3.981	115.75	-40.72	0.05	19.23	3.78	227.75		4.01E+07
2004	100912	3752.5	-4.068	115.06	-39.31	0.17	19.07	3.74	229.39		4.08E+07
2006	100368	3717.8	-4.145	114.40	-38.24	0.35	18.96	3.71	231.12		4.15E+07
2008	99819	3682.6	-4.212	113.71	-38.91	0.17	18.89	3.68	232.81		4.23E+07
2010	99267	3646.9	-4.271	112.99	-39.32	-0.10	18.72	3.65	234.43		4.31E+07
2012	98715	3611.4	-4.327	112.27	-38.40	-0.29	18.48	3.62	236.05		4.39E+07
2014	98161	3576.2	-4.367	111.58	-36.57	-0.21	18.24	3.58	237.65		4.47E+07
2016	97609	3541.7	-4.398	110.91	-35.26	-0.14	18.06	3.55	238.76		4.53E+07
2018	97059	3507.5	-4.423	110.26	-34.64	-0.05	17.86	3.51	239.82		4.59E+07
2020	96512	3473.5	-4.454	109.61	-34.74	-0.06	17.68	3.48	240.84		4.65E+07
2022	95966	3439.3	-4.480	108.95	-34.66	-0.04	17.54	3.44	241.76		4.71E+07
2024	95423	3405.0	-4.508	108.28	-34.83	-0.14	17.36	3.41	242.62		4.78E+07
2026	94882	3371.0	-4.538	107.62	-33.37	0.05	17.19	3.37	243.50		4.84E+07
2028	94343	3336.5	-4.571	106.99	-33.05	0.14	17.04	3.34	244.88		4.93E+07
2030	93807	3302.1	-4.603	106.35	-32.63	0.20	16.94	3.31	246.24		5.01E+07
2032	93272	3267.6	-4.630	105.69	-32.97	0.13	16.82	3.28	247.49		5.10E+07
2034	92741	3232.8	-4.653	105.02	-33.07	0.06	16.69	3.25	248.62		5.19E+07
2036	92213	3197.8	-4.672	104.34	-33.06	-0.00	16.54	3.22	249.63		5.28E+07
2038	91689	3163.0	-4.695	103.66	-32.19	0.09	16.33	3.18	250.55		5.36E+07
2040	91168	3128.0	-4.719	102.99	-31.58	0.13	16.14	3.15	251.13		5.44E+07
2042	90650	3093.5	-4.752	102.33	-30.77	0.25	15.96	3.12	251.64		5.51E+07
2044	90135	3059.3	-4.789	101.68	-30.74	0.32	15.86	3.08	252.12		5.59E+07
2046	89621	3025.1	-4.834	101.01	-32.17	0.20	15.78	3.05	252.52		5.67E+07
2048	89107	2990.9	-4.891	100.28	-33.69	0.08	15.72	3.02	252.83		5.74E+07
2050	88594	2956.4	-4.956	99.51	-34.85	-0.16	15.63	2.98	253.06		5.82E+07
2052	88080	2922.1	-5.012	98.74	-33.26	-0.36	15.47	2.95	253.23		5.89E+07
2054	87568	2887.8	-5.050	98.00	-31.69	0.45	15.37	2.92	253.32		5.97E+07
2056	87057	2853.5	-5.106	97.22	-32.19	0.28	15.21	2.88	253.32		6.04E+07
2058	86547	2819.6	-5.160	96.46	-32.30	-0.13	15.77	2.85	253.31		6.12E+07
2060	86045	2783.2	-5.106	95.64	-31.00	-0.21	14.71	2.81	252.69		6.19E+07
2062	85545	2751.4	-5.219	94.95	-30.35	-0.20	14.29	2.78	252.80		6.27E+07
2064	85044	2718.1	-5.253	94.24	-29.12	-0.08	14.87	2.75	252.59		6.34E+07
2066	84548	2684.4	-5.258	93.54	-30.94	0.27	14.88	2.72	252.42		6.42E+07
2068	84056	2650.7	-5.319	92.74	-33.88	-0.09	14.71	2.69	252.16		6.51E+07
2070	83563	2617.5	-5.407	91.91	-34.81	0.01	14.62	2.65	251.89		6.59E+07
2072	83068	2584.0	-5.512	91.04	-36.30	0.08	14.69	2.62	251.54		6.68E+07
2074	82569	2550.8	-5.643	90.15	-36.95	0.25	14.63	2.59	251.19		6.76E+07
2076	82064	2517.8	-5.795	89.24	-37.27	0.36	14.64	2.56	250.89		6.85E+07
2078	81552	2484.7	-5.941	88.33	-35.08	0.02	14.72	2.53	250.60		6.95E+07
2080	81041	2450.5	-5.930	87.54	-26.01	0.09	14.62	2.49	250.00		7.04E+07
2082	80543	2416.5	-5.830	86.99	-16.93	-0.20	14.21	2.46	249.23		7.12E+07
2084	80063	2382.8	-5.662	86.75	-5.66	0.11	14.24	2.43	248.18		7.20E+07
2086	79605	2348.5	-5.437	86.81	3.78	0.25	14.42	2.40	246.64		7.27E+07
2088	79174	2313.5	-5.195	87.13	12.91	0.04	14.60	2.36	244.51		7.33E+07
2090	78768	2278.6	-4.992	87.72	20.41	0.27	14.76	2.33	241.84		7.37E+07

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
2092	78382	2243.0	-4.803	88.45	22.39	0.10	14.78	2.29	238.70		7.39E+07
2094	78016	2207.9	-4.657	89.23	23.29	0.19	14.55	2.26	235.35		7.41E+07
2096	77665	2173.1	-4.534	90.04	23.65	0.29	14.50	2.22	231.82		7.42E+07
2098	77328	2138.6	-4.424	90.80	21.74	0.06	14.42	2.19	228.14		7.43E+07
2100	77005	2104.4	-4.314	91.51	20.15	-0.16	14.44	2.16	224.31		7.43E+07
2102	76695	2070.1	-4.198	92.17	18.94	-0.34	14.37	2.12	220.27		7.42E+07
2104	76397	2036.4	-4.108	92.81	18.29	-0.43	14.18	2.09	216.17		7.41E+07
2106	76108	2003.6	-4.072	93.40	17.05	-0.58	13.71	2.06	212.14		7.40E+07
2108	75824	1972.0	-4.113	93.96	16.84	-0.50	13.06	2.02	208.29		7.39E+07
2110	75539	1942.0	-4.252	94.52	16.39	-0.10	12.40	1.99	204.74		7.38E+07
2112	75245	1913.5	-4.484	95.01	14.55	0.10	11.76	1.97	201.57		7.38E+07
2114	74937	1886.7	-4.799	95.44	12.86	0.23	11.23	1.94	198.83		7.39E+07
2116	74609	1861.4	-5.192	95.83	11.87	0.36	10.76	1.91	196.54		7.41E+07
2118	74259	1837.3	-5.642	96.18	10.90	0.48	10.43	1.89	194.67		7.44E+07
2120	73884	1814.2	-6.132	96.49	9.57	0.50	10.28	1.87	193.19		7.48E+07
2122	73482	1791.7	-6.632	96.73	7.82	0.27	10.20	1.85	192.03		7.54E+07
2124	73054	1769.5	-7.137	96.95	7.42	0.05	10.14	1.82	191.12		7.61E+07
2126	72600	1747.7	-7.648	97.18	7.86	-0.04	10.04	1.80	190.47		7.68E+07
2128	72120	1726.7	-8.175	97.40	7.35	-0.20	9.93	1.78	190.16		7.77E+07
2130	71616	1705.7	-8.696	97.59	7.66	-0.33	9.90	1.76	190.10		7.88E+07
2132	71087	1684.1	-9.214	97.67	7.16	-0.53	9.91	1.74	190.29		8.00E+07
2134	70535	1662.6	-9.709	97.71	6.53	-0.88	9.94	1.72	190.66		8.12E+07
2136	69963	1640.9	-10.186	97.76	6.96	-1.08	10.02	1.70	191.13		8.26E+07
2138	69372	1619.2	-10.634	97.84	7.60	-1.09	10.05	1.68	191.69		8.41E+07
2140	68765	1597.6	-11.054	97.97	7.55	-0.92	10.04	1.66	192.37		8.56E+07
2142	68145	1577.9	-11.435	98.40	6.53	-0.38	9.93	1.64	193.47		8.72E+07
2144	67512	1558.8	-11.792	98.76	4.08	-0.14	9.87	1.62	194.78		8.90E+07
2146	66868	1539.8	-12.109	99.02	2.50	-0.44	9.84	1.60	196.18		9.08E+07
2148	66217	1520.7	-12.402	99.34	3.27	-0.32	9.72	1.58	197.57		9.26E+07
2150	65559	1500.8	-12.677	99.63	2.77	-0.36	9.69	1.56	198.89		9.46E+07
2152	64897	1479.4	-12.921	99.88	4.93	-0.47	9.74	1.54	200.10		9.68E+07
2154	64233	1458.1	-13.134	100.22	6.19	0.76	9.68	1.52	201.27		9.90E+07
2156	63570	1436.7	-13.309	100.41	4.85	0.70	9.57	1.50	202.34		1.01E+08
2158	62907	1415.1	-13.493	100.58	3.45	0.04	9.41	1.48	203.28		1.03E+08
2160	62246	1393.4	-13.681	100.84	4.30	0.11	9.33	1.46	204.06		1.06E+08
2162	61585	1372.6	-13.894	101.13	4.33	0.33	8.92	1.44	204.84		1.08E+08
2164	60925	1353.3	-14.090	101.39	3.59	0.39	8.74	1.42	205.47		1.10E+08
2166	60264	1334.2	-14.298	101.56	1.38	0.13	8.59	1.40	206.09		1.12E+08
2168	59604	1314.8	-14.502	101.68	0.87	0.02	8.52	1.38	206.54		1.13E+08
2170	58944	1295.6	-14.702	101.76	0.26	-0.04	8.41	1.35	206.93		1.15E+08
2172	58286	1276.6	-14.870	101.76	-0.11	-0.27	8.32	1.33	207.37		1.17E+08
2174	57631	1257.5	-15.013	101.72	0.22	-0.54	8.19	1.31	207.70		1.19E+08
2176	56980	1238.7	-15.173	101.84	2.72	0.02	8.07	1.29	207.99		1.21E+08
2178	56332	1219.8	-15.328	101.89	0.50	-0.13	8.15	1.27	208.10		1.23E+08
2180	55688	1200.4	-15.453	101.89	0.49	-0.27	8.04	1.25	208.04		1.25E+08
2182	55050	1180.5	-15.570	101.95	0.19	-0.23	7.94	1.24	208.71		1.28E+08
2184	54418	1160.7	-15.680	101.92	-1.06	-0.51	7.83	1.22	209.25		1.31E+08
2186	53792	1140.7	-15.799	101.94	0.23	-0.34	7.78	1.20	209.47		1.34E+08
2188	53173	1121.4	-15.877	101.89	0.95	-0.03	7.72	1.18	208.20		1.35E+08
2190	52563	1102.2	-15.908	101.80	-1.14	-0.01	7.69	1.16	206.69		1.36E+08
2192	51962	1083.4	-15.959	101.48	-4.81	-0.43	7.59	1.14	205.12		1.37E+08
2194	51369	1062.6	-16.068	101.22	-4.95	-0.62	7.52	1.11	203.13		1.39E+08
2196	50782	1041.0	-16.256	101.19	-3.72	-0.09	7.55	1.09	200.96		1.40E+08
2198	50201	1020.4	-16.397	101.19	-2.82	0.47	7.71	1.07	198.97		1.42E+08
2200	49627	1000.8	-16.575	101.22	-2.49	0.75	7.52	1.05	197.13		1.43E+08

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
2202	49056	982.1	-16.822	101.26	-2.17	0.89	7.40	1.03	195.51		1.45E+08
2204	48487	965.2	-17.100	101.23	-2.07	0.79	7.36	1.02	194.38		1.47E+08
2206	47918	950.7	-17.354	101.08	-2.10	0.31	7.36	1.00	193.96		1.49E+08
2208	47350	936.7	-17.624	100.90	-0.40	-0.46	7.32	0.99	193.67		1.51E+08
2210	46783	922.6	-17.878	100.94	2.24	-0.63	7.34	0.97	193.26		1.53E+08
2212	46213	911.2	-18.251	101.09	0.93	-0.17	7.12	0.96	193.92		1.55E+08
2214	45637	905.4	-18.668	101.10	0.10	-0.31	7.26	0.95	197.00		1.59E+08
2216	45057	905.0	-18.497	101.20	-0.47	-0.29	8.33	0.95	202.54		1.63E+08
2218	44488	903.4	-18.129	101.31	-0.58	-0.14	8.21	0.95	207.59		1.67E+08
2220	43930	901.6	-17.848	101.34	-0.70	-0.34	7.58	0.95	212.56		1.72E+08
2222	43379	900.2	-17.798	101.55	1.19	0.05	6.64	0.95	217.80		1.76E+08
2224	42826	898.7	-17.964	101.67	0.17	0.08	6.39	0.95	223.06		1.81E+08
2226	42270	891.7	-18.137	101.50	0.92	-0.26	6.48	0.94	224.90		1.83E+08
2228	41714	883.3	-18.312	101.47	2.69	-0.27	6.55	0.93	225.87		1.85E+08
2230	41159	874.8	-18.322	101.44	1.97	-0.28	6.92	0.92	226.73		1.87E+08
2232	40613	866.1	-18.180	101.31	1.40	-0.68	6.82	0.90	227.35		1.89E+08
2234	40075	857.1	-18.115	101.32	2.44	-0.52	6.72	0.89	227.73		1.90E+08
2236	39545	848.1	-18.058	101.33	2.36	-0.31	6.55	0.88	227.95		1.92E+08
2238	39020	840.2	-18.108	101.31	3.47	-0.67	6.27	0.87	228.65		1.94E+08
2240	38497	832.2	-18.315	101.40	4.27	-0.66	6.06	0.86	228.88		1.95E+08
2242	37970	824.5	-18.674	101.55	5.65	-0.60	5.91	0.85	228.82		1.96E+08
2244	37439	818.5	-18.966	101.78	5.11	-0.59	5.92	0.84	230.04		1.97E+08
2246	36905	813.8	-19.168	102.07	4.08	-0.57	5.81	0.84	232.29		2.00E+08
2248	36367	809.1	-19.408	102.32	1.90	-0.73	5.74	0.83	234.27		2.02E+08
2250	35827	804.6	-19.565	102.46	-3.01	-0.44	5.75	0.82	236.21		2.04E+08
2252	35287	800.9	-19.693	102.22	-9.53	0.08	5.60	0.82	238.73		2.06E+08
2254	34744	797.9	-19.932	101.18	-21.15	-0.00	5.69	0.81	241.68		2.08E+08
2256	34195	794.7	-20.353	99.29	-30.46	-0.11	5.85	0.81	244.56		2.11E+08
2258	33637	791.6	-20.778	96.56	-39.25	-0.10	6.33	0.80	247.54		2.13E+08
2260	33071	788.1	-21.166	92.92	-45.94	-0.21	7.32	0.79	250.19		2.15E+08
2262	32498	783.0	-21.571	88.45	-51.64	-0.22	7.85	0.79	251.91		2.17E+08
2264	31917	777.1	-22.204	83.07	-55.52	-0.21	8.44	0.78	253.21		2.19E+08
2266	31325	769.0	-22.821	76.78	-60.46	-0.70	9.27	0.77	252.98		2.19E+08
2268	30723	761.2	-23.711	69.90	-62.89	-0.41	9.31	0.76	252.91		2.20E+08
2270	30105	752.2	-24.634	62.56	-64.62	-0.40	9.95	0.75	252.21		2.21E+08
2272	29471	744.5	-25.661	54.96	-65.38	-0.34	10.14	0.74	252.47		2.23E+08
2274	28819	739.3	-26.766	47.37	-64.28	-0.34	9.24	0.73	254.49		2.25E+08
2276	28144	738.5	-27.847	40.63	-60.97	-0.23	8.70	0.72	259.69		2.29E+08
2278	27451	737.0	-28.267	34.11	-50.32	-0.10	8.79	0.72	264.74		2.32E+08
2280	26768	732.9	-27.109	28.32	-38.56	-0.06	9.43	0.71	267.84		2.35E+08
2282	26128	729.5	-25.175	23.60	-28.96	-0.14	8.50	0.71	270.98		2.38E+08
2284	25537	725.8	-22.944	20.31	-23.84	-0.17	8.52	0.70	273.46		2.40E+08
2286	24996	722.5	-21.340	17.55	-23.04	-0.25	7.75	0.70	275.83		2.42E+08
2288	24495	717.4	-19.458	14.61	-24.94	-0.32	9.06	0.69	276.43		2.44E+08
2290	24051	708.7	-17.262	10.91	-29.22	-0.26	9.32	0.68	273.54		2.43E+08
2292	23664	697.9	-15.300	6.77	-32.18	-0.08	8.48	0.67	268.56		2.42E+08
2294	23314	687.1	-14.078	2.63	-32.57	-0.08	10.26	0.66	263.30		2.40E+08
2296	23013	672.8	-12.186	-1.90	-31.93	0.04	8.65	0.64	254.87		2.37E+08
2298	22738	662.8	-12.027	-5.39	-32.41	0.10	8.62	0.63	249.63		2.35E+08
2300	22473	652.0	-11.722	-9.17	-34.70	0.25	8.52	0.62	243.60		2.33E+08
2302	22211	643.5	-11.942	-12.72	-34.01	0.42	8.41	0.61	239.26		2.31E+08
2304	21946	637.1	-12.322	-16.41	-36.44	0.45	9.07	0.61	236.54		2.30E+08
2306	21677	631.6	-12.414	-20.51	-36.91	0.48	9.61	0.60	234.48		2.30E+08
2308	21409	627.0	-12.478	-24.83	-37.49	0.48	9.92	0.60	232.97		2.30E+08
2310	21144	622.9	-12.412	-29.32	-37.52	0.41	9.88	0.59	231.87		2.30E+08

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (pfe)	VBAR	RNUM
2312	20880	619.3	-12.376	-33.80	-35.69	0.47	9.76	0.59	231.11		2.30E+08
2314	20619	616.1	-12.345	-37.95	-34.89	0.41	9.62	0.58	230.60		2.30E+08
2316	20359	613.1	-12.332	-42.06	-34.63	0.43	9.25	0.58	230.21		2.30E+08
2318	20097	611.0	-12.607	-46.01	-35.11	0.39	9.32	0.58	230.56		2.31E+08
2320	19831	609.0	-12.931	-50.00	-35.38	0.35	8.68	0.58	230.96		2.32E+08
2322	19552	608.5	-13.764	-53.67	-35.72	0.29	8.13	0.57	232.50		2.33E+08
2324	19255	609.0	-14.660	-57.38	-36.69	0.19	7.93	0.57	234.86		2.34E+08
2326	18938	610.7	-15.624	-61.33	-40.10	-0.05	8.49	0.57	238.33		2.37E+08
2328	18604	611.4	-16.262	-65.92	-40.22	-0.01	8.46	0.57	241.34		2.39E+08
2330	18257	611.8	-16.715	-70.50	-38.80	-0.05	8.87	0.57	244.43		2.41E+08
2332	17905	611.9	-16.769	-75.28	-37.42	-0.16	8.94	0.57	247.32		2.43E+08
2334	17554	612.2	-16.584	-79.97	-35.68	-0.27	8.69	0.57	250.32		2.46E+08
2336	17205	612.8	-16.607	-84.20	-34.43	-0.04	8.58	0.57	253.62		2.48E+08
2338	16856	613.1	-16.507	-88.40	-33.68	0.12	8.29	0.57	256.71		2.51E+08
2340	16504	615.3	-16.751	-92.20	-34.48	0.27	8.23	0.57	261.74		2.54E+08
2342	16147	617.5	-16.893	-96.41	-37.63	0.29	8.23	0.58	266.99		2.59E+08
2344	15786	618.9	-16.970	-100.99	-38.30	0.15	8.30	0.58	271.68		2.62E+08
2346	15425	618.7	-16.822	-105.94	-38.57	-0.11	7.86	0.58	274.48		2.65E+08
2348	15064	619.0	-17.014	-110.67	-38.88	-0.45	7.03	0.58	277.78		2.67E+08
2350	14696	620.1	-17.497	-115.10	-35.30	-0.54	6.47	0.58	281.84		2.70E+08
2352	14318	621.4	-17.805	-118.56	-30.45	-0.52	6.14	0.58	286.20		2.73E+08
2354	13934	622.2	-17.793	-121.14	-16.86	0.52	6.48	0.58	290.09		2.75E+08
2356	13555	621.9	-17.493	-122.37	-5.57	0.54	6.11	0.57	293.05		2.77E+08
2358	13182	620.1	-17.263	-122.44	1.73	0.31	5.67	0.57	294.60		2.79E+08
2360	12812	617.3	-17.358	-122.24	0.55	0.27	5.40	0.57	295.19		2.80E+08
2362	12442	613.8	-17.481	-122.10	4.13	0.41	5.30	0.56	295.28		2.81E+08
2364	12071	609.6	-17.447	-121.63	4.26	0.29	5.75	0.56	294.74		2.82E+08
2366	11709	604.2	-16.912	-121.11	4.19	0.51	6.45	0.55	292.91		2.82E+08
2368	11370	596.5	-15.527	-120.56	3.30	0.66	6.83	0.55	288.47		2.81E+08
2370	11064	588.8	-14.539	-120.32	1.79	0.45	5.65	0.54	283.87		2.80E+08
2372	10764	584.5	-15.053	-120.20	1.07	0.17	5.00	0.53	282.33		2.80E+08
2374	10450	582.5	-15.859	-120.20	0.89	0.17	5.27	0.53	283.13		2.82E+08
2376	10124	581.9	-16.599	-120.22	1.30	0.20	5.13	0.53	285.42		2.84E+08
2378	9783	582.1	-17.006	-120.19	0.72	0.26	5.63	0.53	288.59		2.86E+08
2380	9439	582.4	-17.322	-120.31	-0.70	0.11	5.40	0.53	291.77		2.88E+08
2382	9090	582.1	-17.167	-120.45	0.85	0.04	5.91	0.53	294.37		2.90E+08
2384	8750	581.2	-16.719	-120.34	0.53	0.03	5.77	0.53	296.25		2.92E+08
2386	8416	580.2	-16.528	-120.34	-0.68	0.22	5.52	0.53	298.17		2.94E+08
2388	8085	579.6	-16.533	-120.55	-1.71	-0.13	5.47	0.52	300.41		2.96E+08
2390	7754	578.5	-16.446	-120.65	0.57	-0.19	5.53	0.52	302.20		2.98E+08
2392	7425	576.0	-16.516	-120.69	1.07	-0.32	5.23	0.52	303.20		3.00E+08
2394	7095	571.7	-16.698	-120.71	0.27	-0.32	4.71	0.52	302.29		3.01E+08
2396	6760	568.0	-17.395	-120.79	0.88	-0.27	4.58	0.51	301.90		3.02E+08
2398	6415	566.2	-17.603	-120.57	2.12	-0.09	5.18	0.51	302.98		3.04E+08
2400	6072	562.8	-17.516	-120.62	-0.12	-0.63	5.38	0.51	302.25		3.04E+08
2402	5737	556.5	-17.181	-120.87	-0.92	-1.08	4.82	0.50	298.29		3.03E+08
2404	5403	551.5	-17.708	-120.83	1.38	-1.06	4.82	0.50	295.87		3.03E+08
2406	5066	547.0	-17.876	-120.70	1.16	-1.00	5.14	0.49	293.96		3.03E+08
2408	4732	543.7	-17.651	-120.69	0.61	-1.21	5.43	0.49	293.43		3.04E+08
2410	4401	544.1	-17.632	-120.64	1.27	-1.23	5.50	0.49	296.86		3.07E+08
2412	4068	545.9	-17.504	-120.20	1.74	-0.13	6.35	0.49	302.04		3.11E+08
2414	3748	545.6	-16.452	-120.25	-3.04	0.29	6.52	0.49	304.75		3.14E+08
2416	3446	545.1	-15.682	-120.93	-3.00	0.06	6.40	0.49	306.24		3.15E+08
2418	3165	541.8	-13.904	-121.50	-0.04	-0.30	7.13	0.48	304.49		3.15E+08
2420	2921	536.1	-12.049	-121.32	0.22	0.19	7.11	0.48	299.74		3.13E+08

Table B-1. (continued)

TIME (sec)	ALTDE (ft)	VEL A (fps)	GAM A (deg)	HDG A (deg)	SIGMA (deg)	BETA (deg)	ALPHA (deg)	MACH	QBAR (psf)	VBAR	RNUM
2422	2718	527.8	-9.741	-121.42	-2.00	0.72	7.52	0.47	292.38		3.10E+08
2424	2559	517.4	-7.840	-121.90	-1.64	0.62	7.27	0.46	283.75		3.06E+08
2426	2429	510.0	-6.478	-122.19	0.82	0.41	7.44	0.45	276.36		3.02E+08
2428	2325	501.0	-5.096	-122.23	0.35	0.24	8.36	0.45	267.16		2.96E+08
2430	2257	487.1	-2.889	-122.29	-0.48	0.37	7.93	0.43	252.89		2.88E+08
2432	2213	470.5	-2.090	-122.47	-0.42	0.43	8.03	0.42	236.17		2.78E+08
2434	2182	454.1	-1.650	-122.62	-0.02	0.30	7.77	0.40	220.09		2.69E+08
2436	2154	438.5	-1.562	-122.59	0.29	0.20	8.71	0.39	205.29		2.59E+08
2438	2133	422.6	-1.055	-122.54	0.04	0.30	9.38	0.38	190.75		2.50E+08
2440	2119	407.0	-0.657	-122.62	-0.97	0.30	9.19	0.36	176.95		2.41E+08
2442	2111	392.0	-0.100	-123.05	-0.96	0.14	9.16	0.35	164.20		2.32E+08
2444	2112	377.2	0.233	-123.25	0.17	-0.25	8.61	0.33	152.06		2.23E+08
2446	2112	363.6	-0.187	-123.04	1.14	-0.20	8.98	0.32	141.22		2.15E+08

Table B-1. (concluded)

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13. ABSTRACT Descent Best Estimate Trajectory data have been generated for the final Orbiter Experiments flight, STS-40. This report discusses the actual development of these post-flight products: the inertial BET, the Extended BET, and the Aerodynamic BET. Summary results are also included. The inertial BET was determined based on processing TDRSS coherent Doppler data in conjunction with observations from eleven C-band stations, to include data from the Kwajalein Atoll and the usual California coastal radars, as well as data from five cinetheodolite cameras in the vicinity of the runways at EAFB. The anchor epoch utilized for the trajectory reconstruction was 53,904 GMT seconds which corresponds to an altitude at epoch of approximately 708 kft. Atmospheric data to enable development of an Extended BET for this mission were usurped from the JSC operational post-flight BET. These data were evaluated based on Shuttle-derived considerations as well as model comparisons. The Aerodynamic BET includes configuration information, final mass properties, and both flight-determined and predicted aerodynamic performance estimates. The predicted data were based on the final pre-operational databook, updated to include flight determined incrementals based on an earlier ensemble of flights. Aerodynamic performance comparisons are presented herein and correlated versus statistical results based on twenty-two previous missions.				
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